THE ECONOMICS OF MINING

By

T. A. RICKARD H. C. HOOVER
W. R. INGALLS R. GILMAN BROWN
AND OTHER SPECIALISTS

EDITED BY T. A. RICKARD

SECOND EDITION REVISED

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PREFACE

The pages of this book furnish a reprint of a number of articles, bearing upon the cost of mining, which have appeared in The Engineering and Mining Journal between January, 1903, and June, 1905, a period of two and a half years. As affecting the economic aspect of a world-wide problem, I have included a number of articles dealing with those ethical and financial considerations which are no less important to the industry than the scientific principles underlying the actual breaking and milling of ore at the mine. For the editorial comment I am responsible; some of it, in the light of ampler evidence or maturer thought, I would like to change; but any alteration would involve a recasting of the material detrimental to its value as a record of professional discussion during the period mentioned.

T. A. Rickard.

New York, June 30, 1905.

PREFACE TO SECOND EDITION

In bringing out the second edition of this book a few typographical corrections of the pages comprised in the first edition have been made, but otherwise there are no changes except the addition of "Cost of Mining—III," by W. R. Ingalls, completing the series of articles on that subject, which appeared in the ENGINEERING AND MINING JOURNAL after the first edition was on the press; and two articles on "Cyaniding Sulpho-Telluride Ores" and "The Diehl Process," by Philip Argall, which were overlooked in making up the first edition. The first of these articles by Mr Argall appeared in the ENGINEERING AND MINING JOURNAL of July 11, 1903, and was the direct inspiration of Mr. Hoover's article, "Ore Treatment at Kalgoorlie." Mr. Argall replied to Mr. Hoover in a later issue. It is fitting, therefore, that both of Mr Argall's articles should be reproduced in order to round out the discussion of a subject which is still of live interest. These additions have been made with Mr. Rickard's approval.

W. R. INGALLS.

New York, October 1, 1907.

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CAUSES OF FAILURE IN MINING

(January 31, 1903)

To the Editor:

SIR — It has been estimated that 95 per cent. of the commercial and industrial enterprises which are started every year ultimately prove unprofitable. Such business failures are primarily due to incorrect estimation of the trade conditions which obtain in every field of commercial operation. These conditions are innumerable, intricate and constantly changing, but nearly all of them are the result of merciless competition.

There is relatively less competition in the business of mining the precious metals. Yet even with competition largely eliminated, I do not believe that mining enterprises have scored any *less* percentage of failures than the purely commercial, with their increased attendant hazards of endless competition constantly accelerated and intensified by cheaper processes of manufacture and various trade combinations.

In weighing these opposing conditions it would appear as if the investor in mining enterprises should have a better "run for his money" than statistics would seem to indicate.

What are the causes of unsuccessful mining?

There are many causes, some of which might be eliminated if the investor could be shown them. Nearly everyone has, at some time or another, bought mining stock or "taken a flyer"; yet how many of those whose investments have proven disastrous have re-invested or "tried again"? Their speculative fever subsides after the bleeding. As a result, mining engineers are far less busy than they might be, and the development of the mineral resources of various parts of our country is thereby much retarded. A discussion of these conditions, their causes, and their ultimate elimination would be timely, and it might show many unsuccessful investors the proper way to try again.

After a good many years of activity in the mining and metallurgical field, I feel that I can mention a few causes of failure

of mining enterprises and suggest a few remedies. If by writing this introductory letter and inviting the consideration of this subject I can induce some of my fellow-workers to grasp their pens and express their ideas, I believe that the investing public might profit from the discussion.

I. — Starting Wrong

Don't invest money on the strength of a printed prospectus or the advice of an "interested friend" without preliminary investigation by a reliable engineer.

Don't "take a flyer" in mining, but invest your money with the same care and discretion you would use in buying bank stocks, real estate or a silk factory.

Don't trust altogether to luck. Use a little sound business sense.

Don't invest in a mining company that guarantees dividends. Dame Nature has something to say about *that.*

Don't invest in a mining company that is selling treasury stock and paying dividends at the same time. If the mine is earning dividends the company owning it seldom has a legitimate interest in selling more stock.

II. — Investigation and Management

Unless you have had sufficient experience as a mining engineer and metallurgist, and if the amount of your contemplated investment is considerable, employ a reliable, experienced engineer to report on the property. Don't do this yourself unless you are born eternally lucky. Every man to his trade.

Once you have invested in a mining enterprise, insist on frequent and complete reports covering operations of the mine. Employ a competent superintendent.

Don't take your son or your nephew or your clerk out of your store or business house and send him to Arizona or Colorado to "run things" for you at the mine. Sell out first.

Once you are assured of their qualifications, put every reasonable confidence in your manager and superintendent. Give them a fair show to make a dividend payer of your mining investment.

If you are a director in a mining company, do not force the manager or superintendent to find a job for all of your unsuccessful friends and relatives. Let him hire his own men Don't convert your mining property into an asylum for ne'er-do-wells.

III. — Operation of Mines

Don't spend all of your capital on top of the ground. Do some digging. Don't buy too much territory. Mining claims are cheap. Concentrate your operations and your capital at the points where your orebodies have been found. Additional surface territory means *nothing* unless it contains ore.

Don't expect your ore to grow richer with depth. It may gain in *quantity,* but seldom in *quality.*

Don't build a mill or a smelter or reduction works until you are certain you have enough ore available to keep the mill in steady operation until at least its initial cost is recovered. This advice is ancient and worn from constant repetition, yet there are innumerable mills and smelters dotting our Western landscapes to-day which hardly turned a wheel because the supply of ore was insufficient or unsuitable.

Don't build your reduction works until you have assured yourself beyond all doubt as to what kind of a process your ore requires to yield up its values. You can adapt the mill to the requirements of the ore, but you cannot manufacture an ore to run through any particular mill or smelter. Spend time and money in finding out, first, what process is peculiarly adapted to your ore, then you will leave behind you no silent enduring monument to folly. Employ a competent, experienced metallurgist to practically test your ores before building a mill. Most any process works all right on most any ore in a chemical laboratory, but in actual work on a commercial scale there are other conditions to contend with. It is well to find out what these conditions are before spending money on reduction works.

I realize that the suggestions I have made and the remedies I have advanced with a view to insuring greater safety in mining investments, are ridiculously simple and self-evident to the veriest tenderfoot; but this being the case, I will leave it to someone else to state why business men continue year after year to make the same mistakes in their mining investments instead of

proceeding along these lines of *greater safety.* They do not seem to learn by experience, *why*—I do not know. However, I would like to see these gentlemen have a better "run for their money." Can we not help them?

PERCY WILLIAMS.

Prescott, Arizona, January 6, 1903.

THE VALUATION OF MINES

(Editorial, January 31, 1903)

IN this issue a correspondent brings forward a pertinent query concerning the unprofitable result of a large percentage of mining investments. It is a broad question, which may be answered humorously, cynically or straightforwardly, according to the mood of the person interrogated. We can only reply in all seriousness, for it is a subject fundamental to the mining industry. Our correspondent gives a number of indubitable causes for failure, but we think he has omitted the most important of them all. We refer to the over-valuation of mines.

In order to discuss the matter profitably it is necessary to take the simplest case of all, a valuable gold mine Eliminate from the inquiry the undeveloped mines and prospects; disregard, for the moment, the essential uncertainty of all the occurrences of ore in nature and the difficulty of estimating the quantity available; restrict the scope of the investigation so as to avoid the complications due to varying metal markets—so potent for good and ill in the mining of the baser metals; take it for granted that you are dealing with a known valuable deposit of gold ore which can be profitably worked under the given conditions of time and place, and then ask: What can make it the basis of a losing investment?

The answer can include causes as numerous as the many vagaries of human nature, but the principal source of trouble arises, we believe, from over-valuation. The appraisement of mines has undergone striking development during recent years and it merits fuller discussion than the present occasion will permit. A mine may be said to be worth a given sum when it can return that sum as profit from operations covering a term of years, plus the interest on the investment during the period consumed in the return of the stated price. When this is translated into a share capital the conditions are the same, although the amount of in-

terest which should be returned in the form of dividends will vary in percentage according to the hazard of different kinds of mining.

Apart from specific causes, there are several general influences which militate against true values. There is that expectation of better things, that resolute hopefulness which is necessary to all exploratory work. We cannot do without it, but it should be so restrained as to regard the rules of arithmetic. It is natural to the owner, to the manager, to the intending purchaser, to all the persons to whom the success of the mine ministers, directly or indirectly; therefore, all the more reason for taking care that the valuation of the mine be intrusted to those whose judgment is in no wise vitiated either by sanguine sentiment or that disturbing influence which is covered by the term participation To summarize, mines are often over-valued because the valuation is usually done by people who are interested in getting a maximum appraisement.

There is another far-reaching factor; mines are frequently bought to sell. It is a cynical truth that more money is made by selling mines than by buying them—because they are so often sold for more than they are worth. Therefore it happens that although a property may be recognized as worth a stated sum, nevertheless shrewd persons will be willing to pay a larger amount because they have a reasonable expectation of selling it subsequently for still more. If this is brought about by further intelligent development, by solving knotty problems of ore treatment, by a new equipment which minimizes working costs, that is, by engineering talent of the best kind, then assuredly the enhancement in price is both warranted and deserved; but when it merely presumes upon the ignorance of individuals or of shareholders it partakes of the practices which slide imperceptibly into acts that are dishonest.

The result of these tendencies is that it is hard to purchase mines at a fair valuation—that is, we repeat, a valuation such as is likely to give a return of the purchase price, plus a reasonable interest on the capital invested. The supply of good mines is far below the demand; in addition to those who are shrewd enough to recognize that gold mining, if properly safeguarded, is the safest industry extant, there are a larger number who see the advantage of trading upon the sanguine temperament of

human kind, and there is also another class of people who rush in where experienced men fear to commit themselves. Thus, if a mine is worth a certain sum, as nearly as the fact can be determined by skillful and trained specialists, then the first group described will pay that much for it, while the second will pay more according to the popularity of the locality and the attractiveness of the scheme, and the third group, of innocents, will be deluded into parting with a price which, humanly speaking, promises a loss with deadly certainty.

These are some of the reasons why mining ventures prove unprofitable; they are such as time alone can remove—time and the education of the public to a realization of the fact that while no industry affords such rapid and remunerative returns as legitimate mining, none affords so readily the *facilis decensus Averno* which awaits the greedy or the foolish in the financial arena.

ORE SORTING

(Editorial, February 7, 1903)

THE article on ore sorting which we publish in this issue deals with a subject of very practical importance. Ignorance concerning the proper proportion of poor rock which it is desirable to take out of the veinstuff has made failures of good enterprises, and the overlooking of this factor in mining has been at the bottom of many inexplicable over-valuations of property. Whether to sort or not, is a question vital to the economics of a mine; it may mean the choice between a small yield of high-grade material or a large output of low-grade, an alternative which immediately affects all the operations carried on at the surface, as well as underground. In regard to estimates of the future production of a mine, it is not too much to say that the tonnage taken out of the workings is nearly always greater than that calculated, because it is found by experience that such estimates, based as they are on a few regular stopes, are likely to be pitched too low as regards tonnage and too high as regards assay-values; therefore, the stoping widths which are determined by actual measurement should have added to them an allowance for breakages of rock from the walls of the lode and the accidental inclusion of waste in other ways.

The best place to do your sorting is at the working face, if you can; this is to be done, either by judicious blasting, which removes the maximum of clean ore and the minimum of wall-rock, or by eliminating the large pieces of waste which are always serviceable for loading the stulls. All sorting at surface is made more difficult by the mixing which the particles of ore and waste undergo in subsequent handling, either while being loaded into the cars or dumped into the ore-house. The Cornishman who "resues," that is, strips the lode by shooting down the adjoining waste-rock previous to breaking down his ore, separately and clean, presents one extreme of the methods pos-

sible underground; while the man who needlessly blasts a narrow and clean streak of high-grade ore together with several feet of adjoining barren country, only to give employment to a number of men at surface who separate what could have been kept apart in the stope, illustrates the other extreme. It is not a mathematical or scientific question, and on that account it is insufficiently appreciated, but, like many other problems arising in daily work, it demands that fundamental science which Huxley defined as organized common sense.

SORTING AT JOHANNESBURG

BY T. LANE CARTER

(February 7, 1903)

THE question of raising the grade of the ore by sorting out the barren quartzite is one that has received great attention on the Witwatersrand, so that a well-equipped sorting house is now looked upon as one of the necessary features of a complete plant. Sorting by hand is the method pursued, it being out of the question to use such contrivances as jigs for this purpose.

Formerly, the waste rock was considered quite barren, and therefore of no value. A different opinion prevails now. It has been the custom, of course, to take samples of the rock which is thrown out, but such sampling is almost useless for practical purposes. It is, in fact, impossible to determine in the ordinary way how much the waste rock is worth, for it consists of pieces ranging from the size of an egg up to 30 or 40 pounds. One method is to take a handful from each carload of waste before it is sent to the dump, and throw this sample into a box. When the box is full the man in charge of the sorting plant takes a sample of a few pounds in weight, and sends it to the assay office to be assayed.

Now, it is curious how the value of this sample varies, according to the man who is responsible for it. It is possible to obtain a reliable return from the assayer if the rock is properly crushed and quartered, but the question is: Does this sample give a true indication of the value of the rock which goes over the dump?

The only possible way of getting at the value of the waste is to crush everything to a uniform small size, and then quarter down carefully. This is a cumbersome operation, and is not practicable. The writer has known of cases where an assay of the waste, which was put down as 4½ dwt., had a red ink line

drawn through it by those high in authority, with the remark that "it was impossible for the rock to be so rich," and that "the sample must have been wrong." But it is just possible that in some cases such a high value was actually in the rock. On one mine, known to the writer, the management took the latter view, and let out a contract to an experienced man to resort the whole dump. The contractor was given about $4 per ton for every ton of clean ore he picked out, and it was a surprise how many tons of pay-ore were obtained.

A rather practical test is being tried on two of the big mines here. No attempt is made to sort out the waste; everything that comes from the mine goes to the mill, except, of course, the rock from cross-cuts. The value per ton crushed has fallen, but the management believes that under the circumstances more profit will be made by not sorting. The way they look at it is this: A calculation is made of the cost of handling the ore after leaving the sorting table, suppose it is determined that having mined and hoisted the ore and brought it to the mill it pays to crush anything over 1.9 dwt., and the waste-heap goes 2½ dwt.; then it is better to run through this 2½ dwt. stuff, even if only 1 shilling per ton profit is made, rather than hang up a number of stamps for lack of ore.

It is not held that sorting does not pay, but under some conditions it might be preferable not to sort. Take, for instance, a battery of 200 stamps. On account of the scarcity of labor, only about 70 of these stamps can be supplied with sorted ore at the present time. Under these conditions it is advisable to put through every ton of material on which even a small profit can be made.

To put the matter in a nutshell, the managers make profits the basis of calculation, rather than yield per ton of ore crushed. If labor were plentiful, and a mine with 200 stamps had a superabundance of ore, the better policy would be to raise the grade as much as possible, even if by so doing the dump assayed rather high. But it will be many months before a mine with 200 stamps will have a superabundance of ore for the mill.

The enthusiasts on sorting look rather askance at abandonment of sorting, but it is an experiment, and as such is interesting. It will be noticed that 2½ dwt. was put down as the value of the waste rock. This might seem high, but on some mines

it is the correct value An investigation has shown the cause of it. The quartzite country is barren, if sampled a foot from the reef or vein, but sometimes in the immediate neighborhood of the reefs careful sampling will show that the supposedly barren rock carries gold, assaying in one case as high as 1 oz. per ton. The underground manager of one of the Rand mines told me that in his mine there was a tiny pyrite seam, some distance from the regular leader, which assayed 5 oz. to the ton. In the ordinary course of events this country rock would be thrown out.

The foregoing must not be taken as disparaging the scheme of sorting, for there is no doubt that sorting, if carefully watched, and done by skilled men, can play a still greater part in the future of the Rand than it has done in the past. Like everything else, however, it needs careful watching; if it is not done properly, an actual loss might be the result, as has been already indicated.

In the future it is possible that better sorters than Kaffirs will be employed. An earnest attempt will be made to get at the actual value of the waste rock, either by occasional trials in the mill or by careful sampling.

On some mines an attempt at rough sorting is made underground, the larger pieces of waste being put in pack walls. In the sorting houses one of two schemes is adopted Either an endless belt, such as the Robins belt-conveyor, moves past the sorters, who throw out the waste, or a revolving table, ring-shaped, about 35 to 40 ft. in diameter, with a periphery 5½ to 6 ft. wide. The sorters throw the waste into bins below the table. Water for washing the ore is, of course, used plentifully.

It may be of interest to give an example of how the question of sorting affects the valuation of a block of ore in the mine Suppose we have a block of ground 300 ft. long by 120 ft. on the dip of the reef. It is desired to form an estimate of the number of tons, and the value per ton in this block. The assay-plan is spread out and the assays taken, as they are marked, all around the perimeter of the block. On the assay-plans of many mines the assay value of the seams of gold-bearing material and the width in inches are bracketed thus.

15 in. at 19 dwt.
4 in. at 75 dwt

All these values are taken down and the average found.

Suppose the result comes out thus

20 in. at 10 dwt
6 in at 90 dwt,

which we call 26 in at 28 dwt, the average value of the block

The stoping width can, for example, be assumed as 42 in. Since we have 26 in. at 28 dwt., then for a width of 42 in we have 42 in. at 17.3 dwt. To find the number of tons in the block $\frac{300 \times 120 \times 3.5}{13} = 9{,}692$ tons; $9{,}692 \times 17.3 = 167{,}671$ dwt., the gold contents of the block.[1]

We will assume that 35 per cent of the ore will be broken as unsortable fines, and that 20 per cent will be sorted out. The block can then be valued as follows:

	Dwt		Dwt.	
3,392 tons fines at	17 3	=	58,685	(1)
1,938 tons of waste rock at...	1 5	=	2,907	(2)
4,362 tons of sorted rock at .	24 2	=	106,079	(3)
9,692 tons . . .		=	167,671	

By combining (1) and (3) we can reckon that from this block of ground there will be sent to the mill 7,754 tons at 21.2 dwt.

Notice that the waste rock is not considered barren, but is put down at 1½ dwt., which is a normal value.

[1] The figure 13 is assumed as the number of cubic feet of ore in place equivalent to one ton.—Editor.

COST OF SHAFT SINKING BY HAND

(February 28, 1903)

MR. EDWARD H. BENJAMIN contributes to the *Pacific Coast Miner* an interesting statement regarding the cost of shaft sinking by hand in California. The table below gives the record of work in the last 150 ft. of the vertical shaft at the Golden Eagle mine, Lassen County, Cal.—the property of the Lassen Mining Company.

	Shifts.	Wages or Price.	Totals	Cost per ft
Miners (9)	423	$3.00 p'r s'ft.	$1,269.00	$8 460
Topmen (2)	94	2.50 p'r s'ft.	235 00	1 566
Engineers (2)	94	3.00 p'r s'ft.	282.00	1 880
Blacksmith (1)	47	3 50 p'r s'ft.	164.50	1.096
Foreman (1)	47	100 p'r mo.	172.30	1 149
Total labor	705	....	$2,122.80	$14.151
	Quantity.			
Timber	10,976 ft.	$13 per M.	$142.69	$0.951
Lagging	2,520 ft.	35c. a piece	88.20	0.588
Lining boards	2,270 ft.	$14 per M.	31.78	0 212
Cordwood (blocking)	5 cords	$3 per cord	15.00	0.100
Wedges	3,000	1c. a piece	30 00	0 200
Total timber			$307 67	$2.051
Wood (fuel)	25 cords	$3 per cord	$75 00	$0.500
Oil and incidentals			15.00	0.100
Total power cost			$90 00	$0.600
Coal oil	6 cases	$4 15 case	$24.90	$0 560
Candles	6 cases	$6 40 case	38.40	0.256
Total illumination			$63 30	$0 422
Powder	600 lb.	14c per lb.	$84 00	$0 560
Fuse	2,500 ft.	$3.70 per M.	9 25	0 061
Caps	550	$6.25 per M.	3.44	0.023
Total explosives			$96 69	$0.644
Total cost of 150 feet of shaft			$2,680 46	$17.868

Mr. Benjamin adds the following details: "Work was commenced at a point 7 ft. below the 400 level and the shaft was sunk 150 ft. below that point. The work was done by hand drilling, working three 8-hour shifts, with three men on a shift. The ground was taken out 7 by 12 ft. in the clear—for a double-compartment shaft. Hoisting was done with a bucket. The country rock was hard andesite. No water was encountered. The shaft was timbered with 10 by 10-in. sawed timbers, end-plates and centre-braces dovetailed in, and centre and corner posts gained in. The sets were placed 5 ft. between centres, filled and lagged solid behind timbers and each compartment was lined with 1 by 12-in. lining boards set 3 in. apart. The work was completed in 47 shifts, making an average of 3 2 ft. per shift, hoisting 20 tons of material per shift, besides putting in timbers. The timbers were framed by hand by the foreman, who directed the work. Eighteen holes were drilled for each round. No. 2 Giant powder was used. The ground drilled hard, but broke well. The outside holes were kept high and the centre broke first. I do not know of any work done by hand where a better record has been made."

GOLD MINING AS AN INVESTMENT

(Editorial, March 21, 1903)

WE note that our London contemporary, *The Economist*, which represents the best traditions of financial journalism, has finished the publication of a series of articles by its "Special Mining Commissioner," under which title we have easily recognized the trenchant style and fearless expression of opinions which characterize our friend, Mr. J. H. Curle. The concluding article of this series, an abstract of which will be found on another page, winds up with a few home truths and that undercurrent of depressing frankness which we have learned to associate with Mr. Curle's writings.

The burden of these recent contributions to the pages of *The Economist* has been: Gold mines are, with rare exceptions, much overvalued; shareholders do not realize the risk and are satisfied with a rate of interest which is too small, considering that risk; they are careless regarding questions of ore reserves; they end inevitably by over-rating their mines and, in consequence, they speculate foolishly. As a corollary, it is suggested by Mr. Curle that a certain rate of dividend, a certain proportion of ore reserves and a healthy condition of development are essential to any mining enterprise which is to be regarded as an investment.

While we appreciate the service done to the public and, no less, to the industry by advice of this kind, we consider that it tells only half the story, and is calculated to create a wrong impression concerning gold mining.

Legitimate gold mining is not necessarily an investment, nor indeed does even so conservative an industry as farming come always under this label. There are types in both industries which proceed along such well ordered lines and with such consecutive regularity of production that their earning capacity can be safely predicted; but each exhibits variations of procedure which are both profitable and risky in a proportionate degree. In this

country gold mining is not ranked with railroad bonds, save by the unthinking. It is true that there are a few properties which have become developed to such an extent that, like the mines on the Rand, they are, humanly speaking, certain to return a stated sum in capital *plus* a definite interest during the period of extraction, but they are so few that the fingers of a man's hand suffice to count those which he can quote impromptu. The moneyed man who goes into mining to make more money knows this. He does not expect to find a Homestake or an Alaska-Treadwell, and if you cross-examine him you will probably discover that he does not want that type of mine so much as he seeks for a Little Pittsburg, a Chrysolite, a Yankee Girl, a Granite Mountain, an Independence, a Tonopah—that is, the superlatively rich ore deposit which makes as much money in a month as the steady producer earns in five years. In other words, the speculative side of mining has an attractiveness which is at the bottom of the energy with which it is prosecuted, and when you bring it to the dead level of a steady investment you will find that the man of ordinary shrewdness will save time by going straight to his broker and buying bonds or consols.

The Rand—presenting an unusual type of gold mining, minimizing risks and at the same time limiting possibilities—has run away with our cautious advisor. Ordinary gold mining can never come to a strictly investment basis; from the time of the Argonauts to that of Cape Nome it has been, and will continue to be, an adventurous pursuit, attractive to the bold and avoided by the timorous.

Strike out the mines which are not sound investments from the undertakings into which a sensible man should put his money, and you shrivel legitimate mining into a dry business, which would soon wither from want of life. Before the investment basis is reached, the best mining undertaking must as surely pass through several stages of comparative speculativeness as a child must run the dangers of measles and mumps. The biggest fortunes are made during the earlier stages of development, more money is made by selling than by buying mines, simply because the final or investment stage of a first-class mine brings less profit, while it never can quite eliminate the essential hazard.

Mining undertakings come to grief so often, not so much on account of failure to attain an investment basis, but because

they are not put on a business basis. People play the fool and expect miracles to happen. The same procedure would ruin a grocery establishment. Because the occurrence of ore in nature is uncertain, and mining as a consequence must necessarily be speculative, there is no reason for piling human foolishness on the top of nature's niggardliness. Of well-conducted mining enterprises it can be said that they meet with a percentage of success as large, if not larger, than any ordinary manufacturing undertaking. The smashes are more spectacular and the successes are more magnificent in the former case, but the average result does not, as a rule, favor the apparently safer form of industry. We are glad to be able to believe, with *The Economist*, that mining methods are becoming more sane; and we recognize that this consummation is quickened by the good sense contained in such contributions as those to which we have been referring.

MINING RISKS

(Editorial, April 4, 1903)

ACTUARIAL calculations have been successfully adopted in estimating the value of the mines on the Rand. Such a method of appraising mining property may not be applicable to the palpitating uncertainties of ordinary gold veins, which, while they miss the comparative uniformity of the great Main Reef series, yet possess possibilities of bonanzas, the like of which are unknown at Johannesburg. Nevertheless, the introduction of the actuary into the proverbial uncertainties of mining would have seemed a curious departure twenty years ago, and it carries with it a certain suggestiveness which can be expressed by simile.

Mines are comparable to humanity. The new discovery of a prospector is like an infant, born to-day, which may die to-morrow, leaving no record, not even a name. A prospect resembles a young child, rich in possibilities, but hedged around with all the uncertainties of immaturity. The promising prospect may succumb to the measles of bad management, or the whooping-cough of inexperience. In spite of care and equipment neither child nor prospect may survive long enough to make a mark, or, on the other hand, they may outlive the dangers of adolescence and, by reason of inherent quality, they may develop into a mine and a man which outdistance the expectations of their best friends. Again, a child grows to manhood; a prospect develops into a mine. The young man reaches the threshold of a career full of promise and distinction, or, he already manifests the evidence of an early decadence of great natural powers; so, too, the prospect, having passed through the changes of early development, may afford proof of opening up into a property of importance, or, on the contrary, it may have been deepened to the water level only to disclose the fact that either the sulphide ores are less rich than the oxidized product near the surface, or that the material, hitherto docile to simple milling, has become too

refractory for profitable treatment. Another stage of development brings the man to full maturity, with a past of fair achievement and a future of continued usefulness, or it may exhibit the exhausted energies of a waning career; similarly, the mine, having achieved celebrity by means of a prolific output, gives assurance of continued productiveness, or, it may be, already shows signs of approaching impoverishment. Finally, both become old, the man and the mine; and, whether it be long in years or deep in feet, we predict with certainty the eventual exhaustion of splendid powers. Men think all men mortal but themselves; they also realize that all mines must give out at last—all save their own. Thus does the melancholy actuary drive home his sad philosophy.

MINING METHODS AT JOHANNESBURG

BY T. LANE CARTER

(April 18, 1903)

THE greatest expenditure of labor in the mines of the Rand is in getting the rock from the stopes to the cars at the level. The amount of work required to shovel a ton of rock from a stope into the cars depends upon the conditions obtaining in different mines. The outcrop gold mines, where the dip is as great as 70°, have a great advantage over the deep-level companies, where the stopes frequently flatten out to 25°. This flattening, taken with the broken foot-wall, makes it necessary to shovel, over and over again, every bit of rock, before it finally gets into the car.

In the deep-level mines, a good many incline-planes have been installed in the flat stopes, so as to facilitate the handling of the ore. The cars are loaded at any point in the stope, and are then lowered to the level below. They are then detached from the rope and pushed to the chute at the landing station, where the rock is dumped. The installation of an incline-plane is by no means as easy as the same undertaking would be in a coal mine. The road-bed has to be blasted out, and the whole contrivance must be protected against violent blasting. However, so much shoveling is saved by instituting these contrivances that it pays to put them in most stopes of 25°, in spite of the initial heavy cost. In these days of labor scarcity it is doubly imperative.

It may be of interest, seeing that so much has been said lately concerning labor conditions, to mention the methods of managing the workmen. Since the skilled white man receives so high a rate of wage, it is necessary to get as much work out of him as possible. Most of the work underground is done by the contract system, although a few of the leading mines operate entirely on "day's pay," and seem satisfied with their results. When the

day's-pay system is in vogue, the character of underground operations depends, to a large extent, on the mine captain and the shift bosses. If they are inferior or inactive men, the amount of loafing which goes on is surprising. If, however, a mine is fortunate enough to have a thoroughly capable mine captain, who has the gift of managing men, and the shift bosses under him are also alert, the day's-pay system makes a very good showing.

The contract system, however, seems the better of the two. The company never appears to lose by it, although some of the miners receive nearly twice as big wages as they would at day's pay. One advantage arises from the fact that the mine employing the contract system attracts the best workmen, who realize that by this method they are thrown entirely on their own resources, with the chance of earning big wages, if they work both with their hands and their heads.

The modifications of the contract system are of practical importance. Some managers, for instance, employ it throughout the mine, except, of course, for timbermen, trackmen, pumpmen, etc. In such a case every piece of rock is broken by contract. Then there are mines using a combination of day's pay and the contract system; those, for instance, which are traversed by dikes and broken country, rendering it difficult to work the ground on contract.

There is, of course, a limit to the amount a contractor is allowed to make, and this limit varies in different mines, and at different periods in the history of the same mine Before milling operations commence, for instance, when there is great eagerness to push the development in all directions as rapidly as possible, the contractor is allowed to make a handsome sum, month after month, without fear of a cut. On one big mine here, before the war, a thoroughly competent miner could make from $375 to $500 per month during the development stage, but when the mill commenced operations this fell a great deal, so that on this property $250 per month is now about the high-water mark.

Even after the mill starts crushing it is considered no more than fair that contractors in drifts and shafts should be paid higher than men engaged in stoping.

It requires considerable skill and experience to manage the contractors to the best advantage. The mine captain should be an expert judge of ground, and be careful to have the price nei-

ther too high nor too low. He must be just. The writer once worked with a contractor in a drive. It was noticed that for three weeks in the month he worked like a Trojan, but did very little in the latter part of the month. Upon being pressed for an explanation, it was found that he calculated he would be cut if he worked strenuously all the month, so he took it easy after being sure he had done enough to get a good wage. In this case the price was evidently too high. Nor should the price be too low, for if too great a cut is made an efficient man is liable to leave for another mine, where he can make more money. One basis of calculation is that a contractor who works hard every day, and manages to drill 40 to 45 ft. a day, and to blast successfully all the holes, should be allowed to make about $250 per month. With such terms a man must work diligently. If he neglects his work, or is not intelligent about it, he runs the risk of being in debt at the end of the month. There are times, however, when the mine captain recommends that the pay of a contractor who has done poorly be brought up to day's pay, and in such cases the man receives more than he has really earned. Discretion has to be used, for if the contractor thinks he is always sure of at least day's pay he is apt to hang back with his work.

In stope contracts the usual method is to pay so much per square fathom. I do not know of any mines here where the method of paying so much per ton broken is employed. In mines that are run on the contract system, much of the responsibility is taken from the shoulders of the mine captain and put upon the survey department, which is responsible for the measuring of the ground. This is not the place to enter into a discussion of stope measuring, but I trust I shall be able to write a description of the methods used at some future date. The prices paid for stoping vary, of course, in the different parts of the mine, and depend upon the character of the rock, whether the stope is underhand or overhand. The biggest range I know of, in any one mine, is from $14.50 to $17.50 per square fathom. In other properties these prices differ, although there is probably not a stope in the district, at least in the deep level mines, that is being worked for less than $12.50 per square fathom. On the average $16 can be considered the prevailing price along the Rand, at the present time. Contractors are provided with Kaffir labor, for which they

pay 75c. per day per man. They are charged for the stores they use, such as dynamite, fuse, candles, etc., and at some properties they even pay for the sharpening of the drills.

What is a good month's work for a contractor? The number of square fathoms stoped out with two air drills (and it is almost the universal practice for each contractor to run two drills except in the drifts) varies as much as the prices paid per square fathom. From 28 to 46 square fathoms gives an idea of the range. About 36 square fathoms, with two machines working a single shift, may be considered good work. The stopes average 4.75 ft. in width. In drifting there is considerable variation also. In some drifts a round of twelve 5½-ft. holes is made, while others require 16 holes. A man working with one machine in unfavorable ground, one shift per day, is doing good work if he makes 40 ft. per month. Under favorable conditions he may manage 50 ft. per month. The prices for drifting vary from $9 to $10.50 per foot.

Owing to the scarcity of cheap labor there are few stopes being worked by hand-drillers. It would be advantageous in most stopes to substitute drilling by hand for machines, and whenever it is possible it is done. A white miner is given charge of a number of Kaffirs, 30 to 40, and works the stope on contract.

The contract system, which I have tried to describe, is certainly not the doctrine of trades-unionism, which preaches that every man doing the same class of work should receive the same wages per day. But there is a certain amount of trades-union feeling even among the contractors. It is generally understood that a day's work consists of putting in 4 holes, 5½ ft. deep, per machine. When the men are on contract they stick to this standard, and only in a few cases do they try to drill more than four holes for each machine. It has often been tried to persuade them to drill more, but they argue in the usual way, and do not change. What, then, is the advantage of using the contract system, if the men do not drill more holes than they would on the day's pay? In the first place, the men use their heads more. To see the care with which a successful contractor pitches his holes, so as to break the maximum amount of rock, makes one realize the difference between a contractor and a wage miner. Then, too, the contractor is much more careful with his stores, dynamite, candles, etc., and waste is thus reduced to a minimum. And

again, the contractor does not loaf. He attends strictly to business.

Many a manager has been surprised to find how early some of the contractors finish their drilling for the day. It is not an unfrequent occurrence to find a contractor, making good pay, finish drilling operations by 2.30 o'clock every day Blasting is not allowed before 5 o'clock, and except the preparation of the charges, the contractor does nothing from 2.30 until blasting time. It is natural that a manager should try to devise a scheme whereby the company may get the advantage of these idle hours. At first the men were asked to drill an extra hole, whenever possible, the promise being given that the rate per square fathom stoped should not be reduced. They fought shy of the scheme, and preferred to make less, rather than overstep the bounds of the recognized day's work. Then the scheme was tried, and is still being tried on a small scale, of paying the contractors so much per foot drilled, in order that each man may drill the maximum number of feet per shift. By this arrangement the contractor is used as a driller. If the plan works well, no doubt regular blasters will be employed, the contractor having nothing to do with the blasting operations. This method of working contracts seems to have met with considerable success in other parts of the world. So far little success has attended it here. In the first place, by adopting this arrangement, the responsibility for the contracts is shifted from the survey department to the shift bosses, and this is undesirable. Then, again, the miners oppose the scheme as being an innovation. It looks as if in the future, as in the past, the general way of carrying on contracts in the Witwatersrand gold mines will be on the basis of area stoped out, without any reference to the amount of drilling, or the thickness of the stopes.

NOTES ON ZINC MINING

By W. Geo. Waring

(July 4, 1903)

Valuation of Zinc Ores. — The value of any zinc ore depends, (1) upon its percentage content of metallic zinc; (2) upon whether the residuum left after smelting for spelter or for zinc oxide can be profitably treated for gold, silver or copper, or, as in the case of franklinite, for manganese; (3) upon its percentage content of deleterious elements which either deteriorate the product or increase the expense of reduction. Thus, lead and iron in considerable amount detract from the value of ore for the latter reason. Zinc-blende is deducted as an objectionable element in calamine ores, and calamine when found in blende ore is not paid for. Cadmium is deleterious for certain purposes, also antimony and arsenic. Sulphur, which composes about one-third of the weight of pure "jack" or zinc-blende, is not considered as an element of value, because the cost of converting it into sulphuric acid (a necessity at some works) leaves little, if any, profit.

The price paid to the ore producer per unit of metal (a unit here meaning 20 lb. or 1 per cent of 2,000 lb.), therefore, varies with the quality of the ore. Thus in Missouri, where the "assay basis" is $30 per ton for blende concentrate containing 60 per cent metallic zinc, concentrates containing only 20 per cent zinc are absolutely unmarketable; when they contain 40 per cent zinc with little or no iron they are worth 25c per unit of metal, or $10 per ton, with 60 per cent zinc the unit price is 50c., and when they assay 64 per cent zinc the value per unit is 53⅛c., or $34 per ton.

It follows that the miner who fails to clean his zinc ore up to the economic limit, which for zinc-blende ore is held to mean that from 2 to 6 per cent of sand or earthy matter may remain in the concentrate, is throwing away value when he sells the

insufficiently cleaned material For example, 1 ton of the 40 per cent ore above cited is worth but $10; if it can be cleaned to assay 60 per cent, even allowing a reasonable waste of 10 per cent in the operation, it will produce 1,200 lb. of 60 per cent ore, worth $18, a gain of $8. If cleaned to assay 64 per cent, the product would weigh 1,125 lb., and would be worth $19.12.

The only fair and equitable method yet discovered for ascertaining the value of any metallic ore is by assay. Buyer and seller are alike protected by this means, even against direct fraud, provided the usual precautions are taken. These precautions are: (1) That the sampling be thoroughly done as the ore is delivered, and in the presence of both buyer and seller or their responsible agents; (2) that an umpire sample be sealed at the time of sampling; (3) that the percentage of moisture in the ore as delivered be ascertained immediately after the weight is determined. The last proviso is necessary because the assay can only be made upon the dried sample, and therefore represents the percentage content of the ore minus its moisture. Obviously, in settling, it is immaterial whether the deduction for moisture be applied to the gross weight of the ore, or to the price to be paid per ton, or to the product of the weight by the price per ton, but it cannot be applied to reduce the assay value.

Weight and Volume of Zinc Concentrate. — The dry weight of a bin of ore or concentrate may be estimated very closely, if the space occupied by the ore be measured and the weight of the ore per cubic foot is known.

The following data relative to the specific gravity and weight per cubic foot of zinc-blende concentrates and two or three other common constituents of Missouri and Kentucky zinc ores, were obtained from careful tests made in the laboratory of Waring & Son, at Webb City, Mo., and are now for the first time made public.

The minerals tested were pure massive blende from Prosperity, Mo., containing 66 per cent zinc, with about 1 per cent of sulphides of cadmium, copper and iron, and having a specific gravity of 4.05; marcasite (cockscomb pyrite) from the same place; galena from Webb City, Mo.; clean flint from the same place, and average fluorspar from Livingston county, Ky. The samples were crushed to 5-mm. size (1-5 in.) and finer, then assorted by sifting into 4 sizes, namely, 5 mm. to 2 mm. (1-5 in.

to 1-12 in.); 2 mm. to 1 mm. (1-12 in. to 1-25 in.); 1 mm. to 0.25 mm. (1-25 in. to 1-100 in.); lastly, under 0.25 mm., or 0.01 in. The weight in pounds of a cubic foot of each sized material, closely packed and shaken down, was then ascertained, and lastly the weight of a cubic foot of equal parts of the various sizes, mixed, was determined. The specific gravity of each mineral was then ascertained, as given in column 6, below. Since the weight of a cubic foot of water is very nearly 62.5 lb., the weight of 1 cu. ft. of each mineral in the solid state was found by multiplying the specific gravity by 62.5, giving the figures of column 7. The increase in volume brought about by crushing each mineral to the above fineness is shown in column 8, the figures of which are found by dividing those of column 7 by those of column 5.

	1	2	3	4	5	6	7	8
MATERIAL.	Size 1-5" to 1-12"	Size 1-12" to 1-25"	Size 1-25" to 1-100"	Size finer than 1-100"	All sizes mixed	Sp gr	Solid wt per c f	Increase in vol
	Lb	Lb	Lb	Lb	Lb		Lb	
Pure Galena	258.8	238 3	251.2	261 2	319 6	7 38	461	1 442
Marcasite (mundic)	119 5	113 1	121 9	128 3	160.7	4.514	282	1 755
Pure Blende	139 4	130 0	128 3	136 3	170 7	4 05	253	1 482
Fluorspar	100.6	97.8	98 3	100.7	127 9	3 14	196	1 532
Clean Flint	77 9	75.4	71.0	75 1	91.2	2 57	161	1 765

The common statement that vein material occupies twice the space after breaking is, therefore, not quite true of rather finely comminuted minerals; and, as the above results show, the increase in volume varies according to the shape of the particles, since the flint and marcasite break into scales and elongated angular fragments, while the particles of the other minerals are nearly isometric. Pyrite and bornite would no doubt give very different results from those obtained with marcasite.

Specific Gravity and Composition of Zinc Minerals, Etc. — In the following list of zinc minerals, and other minerals usually associated with ores of zinc, the order followed is that of their specific gravities, beginning with the heaviest. The specific gravities given are compiled from standard authorities. The percentage compositions are, however, specially computed, using the International Atomic Weights for 1903, and refer to the theoreti-

MINERAL.	Sp gr.	Lbs per cu. ft	COMPOSITION
1. Galenite (Galena)	7.4–7 6	460	86.58 p c lead 13 42 p c sulphur
2 Cerussite (lead carbonate, lead dry bone)	6 4–6 6	406	77.52 p c. lead, 16 49 p c carbon dioxide, 5 99 p c. oxygen
3 Anglesite (lead sulphate, lead dry bone)	6 3–6 35	395	68 29 p. c. lead, 10 58 p c. sulphur, 21 13 p c oxygen
4. Arsenopyrite (mispickel, arsenical pyrites)	6 0–6 4	387	34 30 p. c. iron, 46 03 p. c. arsenic, 19 67 p c sulphur
5 *Franklinite* ...	5 6–5 9	360	47.63 p. c iron, 18 57 p c zinc, 15 62 p. c manganese.
6 *Zincite* (red oxide of zinc)	5 6	350	80 34 p. c zinc, 19 66 p c oxygen.
7 Pyrite (cube iron pyrite, cube mundic)	4 85–5 2	310	46 58 p c iron, 53 42 p. c. sulphur.
8 Greenockite .	4 8–4 9		77 81 p c cadmium, 22 19 p c sulphur
9. Marcasite (orthorhombic pyrite, radiated, capillary cockscomb, spear, liver, and spongy or cellular pyrite)	4 6–4 8	310	46 58 p. c iron, 533 42 p. c sulphur
10 Barite (heavy spar, barytes)	4 6	287	65 71 p c. baryta, 34 47 sulphur trioxide, or, 58 85 p c barium, 13 73 p. c. sulphur and 27 41 p c. oxygen
11. Pyrrhotite (magnetic pyrite)	4 5–4 6	284	60 41 p c iron, 39 59 p c sulphur.
12. *Smithsonite* (calamine, zinc dry bone, zinc carbonate)	4 40	275	52 15 p c zinc, 30 09 p c carbon dioxide, 12 76 p c oxygen
13. *Gahnite* (zinc spinel) ' .	4 34	270	41.79 p c. zinc, 17 32 p c aluminum, 20 49 p c oxygen
14. Chalcopyrite (copper pyrite)	4 1–4 3	262	34 64 p c copper, 30 44 p c iron, 34 92 p c sulphur
15. *Sphalerite* (blende, zinc blende, jack, rosin zinc, etc).	4 05	253	67.10 p. c. zinc, 32 90 p c sulphur
16. *Willemite* (anhydrous silicate of zinc)	4 00	250	58 60 p c zinc, 27.00 p c silica, 14 40 p c oxygen
17 Garnet (including polyadelphite, grossularite, almandite, pyrope, andradite, spessartite, bredbergite, ouvarovite, etc.).	3 5–4 3		35 to 53 p. c silica, 15 to 27 p c alumina, 25 to 40 p c iron, with lime, manganese, etc
18. *Marmatite* (black jack, brown blende, etc)	3 85–3 90	240	45 to 55 p c. zinc, 10 to 18 p c iron and manganese, 33 to 36 p. c. sulphur.
19. Siderite (iron carbonate).	3 8	237	48 23 p c iron, 37 96 p. c carbon dioxide, 13 81 p c oxygen.
20. Hydrozincite (zinc bloom, marionite, earthy calamine) . .	3 75	234	60 5 p. c zinc, 13 6 p. c carbon dioxide, 11 1 p c water, 14 8 p. c. oxygen.
21 Rhodonite (heavy pink spar)	3 4–3 9	228	41 85 p. c manganese, 45 97 p c silica, 12 18 p c oxygen
22. *Silicious calamine* (ordinary zinc silicate) .	3 45	216	54.22 p c zinc, 25 00 p c silica, 7 50 p. c water, 13 28 p c oxygen
23 Fluorite (fluorspar)	3 18	200	51 21 p c calcium, 48 75 p c fluorine
24. Dolomite (bitter spar) . .	2.8–2 9	178	30.41 p. c. lime, 21 88 p. c. magnesia, 47 71 p c carbon dioxide,
25 Calcite (calc-spar, lime-spar, tiff)	2 72	170	56 01 p c lime, 43 96 p c carbon dioxide, or, 40 06 p c calcium, 11 99 p c. carbon, 47.95 p c oxygen
26 Quartz (flint, etc)	2 65	166	47 02 p c silicon 52 98 p c oxygen
27 Selenite (gypsum) . .	2 03	146	32 58 p c lime, 46 49 p. c. sulphur trioxide, 20 93 p c water
28 Kaolin (china clay)	2 21–2 26	140	20 92 p c aluminum, 18 53 p c oxygen, 46.64 p. c silica, 13 91 p c water

cally pure minerals. It must be borne in mind that some of the minerals named are very rarely found in a state of perfect purity. Thus blende nearly always contains from 0.2 to 1 per cent of other sulphides than that of zinc, while marmatite, pyrrhotite and chalcopyrite are very variable in composition.

Assay Results as a Guide in Ore Dressing. — The assay of a sample of zinc-ore concentrate, showing the percentage of each metallic element, as zinc, iron, lead, etc., gives the mine manager a means of detecting defects in the mill work. If the character of the minerals composing the ore be known, the percentage of each mineral, of which one element is determined by assay, may be computed from the data of the last column in the preceding table.

Thus in a lot of concentrate consisting of blende, pyrite, galena and sand or earthy matter, the percentages of zinc, iron and lead being known by assay, the proportion of blende is found by multiplying the zinc by 100 and dividing by the percentage of zinc in blende (67.10), and similarly for pyrite and galena. The sum of the percentages so found, deducted from 100, shows about the proportion of sand or earthy matter in the material, a fact often very desirable to know.

Another method is to multiply the percentage of each element found by assay, by a factor obtained for each mineral by dividing its molecular weight into the atomic weight of the element.

The following incomplete list of such factors, also specially computed from the International Atomic Weights for 1903, will be found of use to mill managers as well as assayers:

Metallic zinc	× 1.49	= Zinc blende.
Metallic zinc	× 1.844	= Silicious calamine.
Metallic zinc	× 1.9174	= Smithsonite (carbonate).
Metallic zinc	× 1.7064	= Willemite.
Metallic zinc	× 1.6526	= Hydrozincite.
Metallic zinc	× 1 2446	= Zincite (zinc oxide).
Metallic zinc	× 5 385	= Franklinite.
Metallic iron	× 2.144 (or $2\frac{1}{7}$)	= Pyrite.
Metallic lead	× 1.155	= Galena.
Metallic lead	× 1.464	= Anglesite.
Metallic lead	× 1 29	= Cerussite (lead carbonate).
Metallic copper	× 2 887	= Chalcopyrite.
Sulphur	× 3.04	= Zinc blende
Sulphur	× 1.8718	= Pyrite.
Sulphur	× 7.4535	= Galena.
Lime	× 1 7856 (or $\frac{100}{56}$)	= Calcite
Lime	× 1 3945	= Fluorite (fluorspar).
Lime	× 3 072	= Selenite (gypsum).

GOLD MINE ACCOUNTS

(July 11, 1903)

The Editor:

SIR—I am glad to accept your invitation to make some remarks on the subject of gold-mine accounts. All efficiently managed mines these days have systematized accounts showing in result the working cost per ton of ore But there is a most harassing lack of uniformity in the method by which the last result is arrived at, and in this, some discussion in your esteemed JOURNAL could be most useful.

First and foremost, mine accounts should be systematized in such a manner as to prevent fraud, and should be so presented as to carry conviction of honesty to the owners. Second, the accounts should be prepared in such a way as to show the expenditure in various departments on some unit basis, so as to enable the manager and his staff to compare results of various departments and various periods within his own mine and also to compare results with his neighbors, that he may be assisted in his intermediate campaign for economy and improvement. Third, to be presented in such a way that the owner, director, shareholder or what not may, for himself, by comparison, determine something of the efficiency of the manager.

At the outset I do not want some half-baked person to rise and remind us that the varying conditions (under which mines of different countries work, or mines of the same country, for that matter, or even mines on the same vein, or even different parts of the same mine) may render comparisons misleading. We all know that the factors which govern working costs are labor, supplies, size of orebodies, character of the ore, volume of ore treated, depth, etc., etc., and that these factors are never precisely the same in any two mines, nor for any two months, and that *pro-forma* comparisons may give the best man a black eye and put an inefficient man on a high pedestal. But all this does not render comparisons valueless, for in the hands of the man who

knows the conditions these same working costs enable the manager to determine very quickly the avenues for improving the efficiency of a department, or permit the owner of the mine to determine the efficiency of the manager himself. The rivalry growing out of such comparisons in its incentive to economy and highest efficiency, when tempered with capacity, has been by no means the least factor in reducing gold mining from an absolute speculation to an industrial enterprise. In order that these valuable influences should have full play, there is a crying need for greater uniformity in the formulation of mine accounts into the ultimate results of working costs. This is not a new idea, but the usefulness of it is more evident these later years, because of the constantly increasing publicity given to working results by reason of the large proportion of mine ownership by public stock companies. This publicity of accounts renders results available for comparative purposes.

The first purpose of accounts requires no discussion here, for it is a matter of competent book-keeping, and deflections are matters for the police to look into. The greatest possibilities for usefulness of the second and third purposes depend upon uniformity on the same mine and on neighboring mines, and still better, on all mines. As said, all well-managed mines show results of expenditures in working costs on tonnage basis, but the variation in method of allocation of expenditures to various departments differs most harassingly. In the first instance, in America and South Africa the short ton is used, while in Australia and India the long ton is used, and therefore the latter are 10 per cent different. In most English-owned mines expenditure is divided into "Capital" and "Revenue," development and construction being generally charged to the former, and written off the latter and thus to working costs, by redemption or depreciation, and a wide variation exists in both the character of the expenditure charged to capital in the first instance, and in the amount charged off afterwards. For instance, in development, some managers charge winzes and raises to development, and others to stoping. Some even charge repairs and renewals to capital, on the theory that they keep the plant up to a fixed state of efficiency. In writing development off by redemption or depreciation, some companies do it on the basis of the average cost per ton developed, others, to beat the income tax commis-

sioner, write off all he will allow. Some companies write off depreciation of plant on a known life for the mine, others on a hoped-for life. Some companies distribute a part of the general charges over capital expenditure, others charge it all off to revenue at once. Some managers charge pumping to ore extraction and some partly to development, while others charge it partly to milling, as being the source of mill water. In ore treatment, some companies give cost of treatment on one generalized figure, which is valueless for comparison, because one ore may involve one operation, while another may involve five. Most companies distribute treatment costs over the whole tonnage milled, yet the proportion of tailing treated by cyanide, for instance, may vary from 50 per cent on one mine to 100 per cent on another. Some companies deduct the cost of realizing bullion from their receipts, while others charge it to working costs, etc., etc., *ad infinitum.* In a few instances there is evident intention on the part of the management to obscure real costs, but in most it is merely difference in method and of opinion. Another feature worth discussion is how far expenditure for dissection of costs is warranted by results to be attained, and how much detail can be used within the realm of accuracy. It is on these matters where, if an agreement could be reached, discussion would be most valuable. It might be a work for the American Institute of Mining Engineers and the English Institution of Mining and Metallurgy to appoint a commission to formulate some plan of working cost statements, as a result of such discussions. I am sure the profession would loyally introduce and adhere to such a plan, and it would meet the approval of the mine owner at the same time, for the results could not but be beneficial to him in the end.

H. C. HOOVER.

London, June 16, 1903

THE PAYMENT OF EXTENSIONS OF MINING PLANT OUT OF REVENUE

By Edward Walker

(July 11, 1903)

In a recent London letter I referred to the principle laid down by Mr. C. Algernon Moreing at the meeting of shareholders of Great Fingall Consolidated, that all expenditure on development of a mine and extension of metallurgical plant should be paid for whenever possible out of revenue. The question before the shareholders was whether the new plant should be paid for by additional capital raised by the issue of new shares, or whether the large balance of divisible profit (some £100,000) should be devoted to that purpose.

The incident opens up the general question of the suitability of the ordinary methods of accounting to the special case of mining, and some discussion of the subject would be opportune.

The method of keeping accounts of mining companies as adopted in London, differs in no way from the standard system for commercial and manufacturing enterprises. All preliminary expenditure on property and plant, subsequent expenditure on extensions, and the cost of sinking shafts, are charged to capital; and current expenditure on labor, supplies, maintenance, and renewals are charged to revenue. This is the theoretical principle, but the method of carrying it out depends upon the circumstances of each individual case. It need hardly be said that the great desire of directors is to show that they can declare a dividend, and whenever extra expenditure becomes necessary for the purpose of sinking a new shaft, or providing additional or improved plant, there is always an inclination not to interfere with the dividends, but to issue new shares. If the mining market is brisk, and if the directors are held in good esteem, owing to their successful management of the property, there is very little difficulty in

raising the additional capital. If, however, the market is depressed, and the directors do not, for one reason or another, care to ask for subscriptions to new shares, then the extra expense is met out of revenue if possible. In other cases, when it is impossible to issue new shares and when there is not sufficient accumulated profit to meet the required expenditure, temporary loans against the ore reserves or against the general assets of the company are made by directors, shareholders or others, and the loans afterwards paid out of revenue.

Typical examples of the various methods of meeting extra expenditure may be given. The method of providing for it by the issue of new capital is well exemplified by the case of the various gold mining companies operating in the Kolar District of India, under the management of Messrs. John Taylor & Sons. Whenever money has been required for increasing the plant it has been raised by issuing new shares, although the mines at the time may have been yielding profits larger than the amount required. For instance, the Mysore Gold Mining Company has paid over three million pounds in dividends, but during its dividend-paying life no less than £645,000 has been raised by the issue of new shares for the purpose of meeting expenditure on additional plant, on the general overhauling of property, and on sinking new shafts. The original capital of the company was £135,000, and at six different times new shares have been created of a nominal value of £122,500. As these shares were all issued at substantial premiums, the cash received amounted to £645,000, as above mentioned. In addition to these shares issued for cash, shares of a nominal value of £32,500 have been issued for the purchase of adjoining properties, so that the nominal capital of the company at the present time is £290,000. This policy has always been unanimously agreed to by shareholders in the Indian group, and as a matter of fact the new shares are usually absorbed by shareholders *pro rata*.

An illustration of the second method of paying for extensions is to be met with in the case of the Great Fingall Consolidated, already referred to. Examples of this policy are also to be found in the companies controlled by the Exploration Company. The Tomboy Gold Mines, Limited, was floated by the Exploration Company in 1899, with a capital of £300,000. In 1902 additional plant, to the extent of 60 stamps and accessories, was erected

and paid for entirely out of revenue. In addition to this, when the original Tomboy Mine showed signs of exhaustion, new properties adjoining were acquired out of revenue, without it being necessary to issue any more shares. El Oro Mining & Railway Company also presents another example of the policy of the Exploration Company. An addition of 100 stamps is now being provided from revenue. In this case, adjoining properties were acquired by the issue of new shares as purchase price. These new properties added to the capital value of the possessions of the company. The original property was showing no signs of exhaustion, as was the case with the Tomboy, where a new property was acquired in place of the old one, rather than in addition to it.

A good example of the third way of providing extensions is to be found in the Great Boulder Perseverance, Mr. Frank Gardner's chief West Australian property. This mine was originally floated in 1895 with a capital of £175,000. After the first three years the oxidized ores came to an end, and great difficulties were experienced in finding a suitable process for treating the refractory ores. There were no surplus profits available for experiment or for erecting a large plant. The cost was entirely borne by Mr. Gardner and his friends, and the amount, something like £150,000, has since been repaid out of profits.

Having mentioned the usual methods of mining-company finance adopted in London, I will proceed to discuss the general question as to the applicability of the ordinary methods of accounting to the special case of mining. It is held by a great many professional men connected with mining that far less expenditure should be charged to capital account, and that the figures at which the original value of the property and plant stand among the assets, should be reduced as rapidly as possible. A mine is not a permanency like real estate, and the value of the machinery depends almost entirely on the supply of ore. Some alteration should therefore be made in the usual practice of entering up the price paid for the property and equipment at unalterable figures. It is true that most of the carefully managed mining companies make allowances every year for depreciation of plant, but few make any provision for the depreciation of the property itself. The consequence is that shareholders receive dividends which they regard as profits, and concurrently the value of the

shares decreases. The real profit of the transaction in buying mining shares is the difference between the original purchase price of the shares and the sum of the total dividends added to the eventual price of disposal of the shares. We have the continual phenomenon in London of profits to mining shareholders concurrent with a gradual or sudden loss of capital.

Such a method of managing mining companies' finances is illogical. Some part of the profits of each year's work should be devoted to the reduction of the capital account, and all expenditure subsequent to the initial cost of the property and equipment of the mine should be paid out of the revenue The method of reducing the value at which the property and original plant stands in the balance sheet would depend largely on circumstances. It might be agreed from the first that, say, one-fifth of the value should be written off every year, and when the total assets had thus been replaced by cash, there might be a return of capital. Another plan would be to have a revaluation every year, and, if the value of the ore reserves was less than at the beginning, to replace the deficiency with cash from the year's profits

It might also be suggested that the nominal capital at the end of every year should be rearranged so as to represent the actual value of the properties, but this scheme would lend itself to much abuse, in addition to which the legal fees and government taxes would swallow up far too much money.

It is not often that a rearrangement of the nominal capital of a mining company, so as to bring it nearer the real value of the property, takes place; as a rule, it only happens when a mine has become exceedingly prosperous and the dividends paid are so high that the market quotation for the shares is greatly enhanced. Then, for the purpose of facilitating market dealings, the nominal capital of the company is expanded so as to bring the current quotation nearer par. Recent examples of the capital being reduced, when it was found that the properties were nearing exhaustion, are to be found in the case of Mason & Barry, and the Mountain Copper Company. In the former case certain proportions of profits were distributed to shareholders, not as dividends, but in reduction of the capital, while in the case of the Mountain Copper Company, the company was reconstructed and the shares exchanged for debentures which are redeemable out of the profits.

Discussion on the subject would not be complete without a reference being made to the incidence of the income tax on the profits of mining companies. As in the case with directors, so it is with the income-tax commissioners. They like to be able to show a large profit. They are very jealous of the allocation of profits to what they call capital expenditure. Very little is allowed in the way of writing off for depreciation of plant, and profits applied to the extension of plant and the sinking of new shafts are invariably assessed. In the case of the Mysore company, if the extensions had been paid out of revenue, instead of the profits being divided and new capital issued, none of the profits thus allocated would have escaped the income tax Similarly, the profits of El Oro and the Great Fingall, used for the purpose of extending the plant, have been assessed. The commissioners would never dream of accepting the proposition I have made for conducting the finances of a mining company, but that is no reason why the system should not be adopted.

This subject is capable of considerable discussion, and I hope that your readers will contribute their opinions and experiences.

ORE TREATMENT AT KALGOORLIE

(August 15, 1903)

The Editor:

SIR—In your issue of July 11 Mr Philip Argall contributes some valuable discussion regarding the Diehl process as relating to Cripple Creek ores. As Mr. Argall's information regarding the progress of metallurgical practice at Kalgoorlie seems to be three years behind, and therefore his basis of argument wholly erroneous, I trespass upon your space to give some recent and detailed costs. Aside from other matters, I think I can show to Mr. Argall that he is wholly unwarranted in believing that the roasting processes must ultimately prevail at Kalgoorlie. Much progress has been made in both processes at that place, and Mr. Argall's figures, which were taken in the early stages of sulphide treatment, do great injustice to both methods.

I think I can do no better than to give the detailed costs in the Lake View mill, choosing that one because it is treating an ore of similar character and a tonnage more comparable to the tonnages handled by the large roasting plants at Kalgoorlie. The Lake View mill, however, will not ultimately be the best advocate of the wet-milling bromo-cyanide method, for it is an adapted plant with a stamp-mill of bad design and construction for a basis, and the accessory plant is not arranged to best advantage. Moreover the power plant on this mine (now under construction) is the worst on the field Yet, even with these handicaps, the results are far different from those upon which Mr. Argall, probably for lack of more recent data, has formed his judgment.

I have taken the month of March as an average period, because, since that time, experiments with a 50-ton daily plant of another process have been in progress and have been charged into costs, somewhat confusing issues; the costs given, however, are a fair average. I have reduced all tonnages and costs mentioned in this communication from the long ton to the short ton, so as to be on the footing of American practice.

During the month a varying portion of a 70-stamp mill treated 8,444 tons with a duty of 5,191 tons per stamp per day. The costs include superintendence, etc, but not depreciation. Water does not include boiler-feed, which is included in power. The costs of milling and concentrating 8,444 tons were, per ton:

Milling—	
Salaries and wages	$0 0997
Water	0 0257
Supplies	0 0417
Maintenance	0.1500
Power	0.3514
Assaying	0.0037
Total milling	$0.6722
Concentrating—	
Salaries and wages	$0.0896
Water	0 0257
Supplies	0.0028
Maintenance	0 0208
Power	0 0404
Assaying	0 0019
Total concentrating	$0 1812
Total, per ton milled	$0 8534

The costs of treatment of 7,962 tons of tailing were as follows, per ton:

Salaries and wages	$0 5040
Potassium cyanide	0 4514
Bromo-cyanide	0 4277
Lime	0 0322
Zinc shavings	0 0119
Sulphuric acid	0 0090
Other supplies	0 0793
Water	0.0271
Maintenance	0 1610
Power	0 5274
Assaying	0 0405
Total, per ton of tailing	$2 2715

The costs of roasting and cyaniding 482 tons of concentrate were as follows, per ton:

Roasting—	
Salaries and wages	$0 9497
Fuel	0 3157
Supplies	0.0368

Roasting—(*continued*)	
Transport and drying of ore	$0 4050
Maintenance	0 0443
Power	0.2354
Assaying	0 0847
Total	$2 0716
Cyaniding—	
Salaries and wages	$0 5391
Potassium cyanide	0 6763
Sulphuric acid.	0 0193
Lime	0.0114
Zinc shavings .	0 0314
Water	0 0859
Other supplies	0 1809
Maintenance	0.3593
Power	0 6029
Assaying	0 1428
Total	$2.6493
Total cost, per ton of concentrate .	$4 7209

Combining these statements of cost, and reducing all the averages to the basis of tons milled, we obtain the following results:

Milling and concentrating	$0.8534
Treatment of tailing	2.1422
Roasting and cyaniding concentrate	0.2699
Total cost per ton milled	$3.2655
Royalty. .	0.1069
Total cost. .	$3 3724

The yield was about $14 per ton, the extraction 92 per cent, and of this 65 per cent was secured from the concentrate and therefore did not pay royalty. The defective arrangement and construction of the mill and power plant resulted in a cost for power and maintenance alone in excess of these costs on the Oroya Brownhill of 38.5c per ton, although the latter treats but 4,000 tons per month, so it must be obvious that a well constructed plant on the Lake View would work at a cost of under $3 per ton. The Ivanhoe plant, now in course of alteration to treat 12,000 tons per month, will work for not over $2.75, probably $2.50. The Oroya Brownhill mill is now in course of enlargement and alteration, and when complete, although treating the most difficult ore on the field, should show also good results. However, the figure of $3 above is sufficient to show the er-

roneousness of the figures of $7 86 in one instance and $5.77 plus royalty in another, as quoted by Mr. Argall for the Diehl costs.

Lack of equally recent and detailed data from the larger roasting mills at Kalgoorlie renders comparison of costs difficult. The annual report of the Great Boulder for 1902 shows the costs on that mine to be $5 per ton, but this has been somewhat reduced since, I believe The Great Boulder Perseverance, treating about 12,500 short tons per month, gives the latest results, with the largest tonnage on the field, at $3.65; but what items are included I do not know.

The wet-milling bromo-cyaniding method requires about 20 per cent less power than the dry-milling roasting method, and involves less cost of maintenance, and also involves not over 70 per cent of the first cost, and therefore less depreciation; and above all it avoids drying the ore and roasting 94 per cent of it. These economies are accomplished practically at the extra expense of concentration, bromo-cyanide and royalty. The use of bromo-cyanide partly replaces potassium cyanide otherwise required, and altogether on the Lake View these special items involve about 70c. per ton. On the other hand a dry crushing mill of the same tonnage, treating Lake View ore for extra drying, extra power, extra roasting, extra cyanide and extra wear and tear, would involve fully $2 per ton.

There is nothing very novel in the Diehl process beyond the well understood methods of stamp-milling, concentrating and cyanide treatment of gold ores, except the grinding of the entire tailing to slime and the addition of bromo-cyanide. The rationale of the process makes much toward economy and steady improvement. The royalties expire in another four years, but aside from this I think I have shown that there is no prospect of displacing the process in that region in favor of dry crushing and roasting, especially as the comparative extraction seems to favor the wet method.

Many details of Mr. Argall's understanding of Kalgoorlie practice are altered by present practice, more especially the fact that the dry-crushing roasting mills grind all ores to slime for filter-press treatment, instead of treating a portion by percolation as he states. The wet-crushing mills do not return roasted concentrate to the battery. Kalgoorlie metallurgists do not have the same apparent aversion to filter-press treatment of tailing as Mr.

Argall The economy of percolation of sand over agitation and filter-press of slime for a period of six months on the Ivanhoe is but 40c. per ton, beside the cost of grinding, of which a portion would disappear in the greater economy of filter-pressing if the whole product were so handled. The compensating advantage, in extraction by fine grinding, considerably more than makes up this difference in either process.

As to the relative merits of the two processes, as applied to Cripple Creek conditions, I am not sufficiently informed as to the character of the ore to offer a judgment, having only been on that ground for a few days; but I might point out that power costs at Cripple Creek are not 15 per cent of that at the Lake View mine, that the cost of water would be almost nil, the cost of cyanide and other supplies less, and that the treatment of concentrate would be much more economical. These four items would permit treating Lake View ore under Cripple Creek conditions with a well constructed mill of, say, 8,500 tons capacity, for not over $2 per ton. A point worthy of consideration by Cripple Creek operators is the adaptability of this process for erection on the mines themselves, and therefore the avoidance of freight charges and customs-mill profits and especially the possibility of modifying the practice to take advantage of some of the more favorable characteristics of Cripple Creek ores, as compared to those of Kalgoorlie.[1]

H. C. Hoover

London, July 29, 1903.

[1] In a former article on the subject Lake View costs were given, including transport to the mill; in this statement, for comparative purposes, they have been omitted. It is especially pointed out again that the above costs are upon a short-ton basis.

GOLD MINING ACCOUNTS

(August 15, 1903)

The Editor

SIR—In your issue of July 11, Mr. H. C. Hoover, at your request, opens for discussion the subject of gold mining accounts. Being associated with the management of a number of very prosperous mines in various parts of the world, Mr Hoover speaks with the authority of one in a position to know and one who appreciates the value of uniformity in the treatment of expenditures of capital and of revenue and in the keeping of mining-costs accounts.

In the business of mining, custom has not yet established a uniform method of charging expenditures for development or for the extension, renewal and maintenance of machinery, plant and equipment. Owing to the varying conditions under which most mining ventures are financed and managed from the head office—leaving the varying conditions at the mine out of the question—it is doubtful if uniformity in these particulars can, or ever will, be attained. But it is possible, and quite within the province of the profession, to urge a consistent degree of uniformity in the practice of stating, if not of keeping, mine working costs. The suggestion that a commission of the technical societies be appointed to take up this work ought to meet with favor.

Discussion of the feature suggested as to "how far expenditure for dissection of costs is warranted by results to be attained and with how much detail it can be done within the realm of accuracy" might lead to a more general discussion of the whole subject of cost keeping.

The results to be attained, or in other words, the benefits realized by a frequent, regular and systematic dissection of working costs, are commonly acknowledged. Economies are accomplished, and a material reduction of mining costs is effected in the saving of time, energy and money. It is possible to secure specific and detailed information of the costs of work at the

time of, and during, its progress. A better opportunity is afforded for making a critical discrimination between capital and revenue expenditures, as the legitimate operating expenses are written off each month. And the manager, depending with full confidence upon his monthly cost-sheet, is relieved of a mass of detail and his mind is free and clear for directing current operations and planning for the future. But probably the most important result, and not so generally understood, is the thorough industrial organization promoted by the conserving influence of a system of cost keeping. A department for finding costs must be supported by the various operating departments. Regular written reports—the cement of commercial organization—are required from foremen, time-keepers and others, from which are secured the data for recording, segregating and distributing the expenditures for labor. Reports and records from the stores department maintain a systematic and complete control over the distribution of supplies. In this way responsibility is fixed, coöperation is secured, the active interest of every employee is enlisted, and a criterion of efficiency established. Upon the theory that the person who lacks enthusiasm in himself can never arouse it in others, this effectual inter-staff collaboration is preserved in the knowledge that the manager is personally interested in and carefully scrutinizes each month's statement of costs. And the best of it is that by virtue of this same organization, of which cost finding is but a detail, these results and benefits are secured at practically no expense whatever. That is to say, a comprehensive system of cost-keeping may be established and maintained at no increase of expense for clerical assistance or otherwise. For the work as it comes into the accounting department can be so methodized that the regular staff usually employed at the mine office can easily handle it. As to how elaborate a proper dissection of costs can be made, it can be asserted with reasonable assurance that the development of a system of cost-finding need depend only upon the amount of detailed information that can be used by the management. The actual operation of a practical system of mine accounting in effective service at the War Eagle and Center Star mines, of Rossland, B. C., has proved this. And the same experience has demonstrated that such a system can be perfected and conducted which will exhibit in accurate detail, from ink to interest, the segregation of expenditures for

labor, supplies and indirect expenses, and their determinate allocation to each and every stope, drift or other heading, separately, in which work is in progress.

This experience and this statement relative to the expenditure necessary to carry out an effectual system of cost-keeping is submitted in the hope that, with the edge taken off the question of expense, a more general discussion of other and more important phases of the subject will follow.

CHARLES V. JENKINS.

Rossland, B. C., August 1, 1903.

MINE VALUATION BY GOVERNMENT

(Editorial, August 8, 1903)

AMONG the various proposals for enlarging the duties of a paternal government, the most startling up to date is that which was seriously made in London by the President of the Council of West Australian Mine-owners, who suggested that a general inspector of mines be appointed by the State government with a view to periodical visits for the purpose of sampling and checking the ore reserves and estimating the value of the producing mines. Furthermore, this inspector was to receive a salary which should "place him beyond the pale of temptation." At the meeting, Mr. H. C. Hoover pointed out the absurdity of the idea, but it seems to have been taken seriously by a number of those interested in West Australian mines.

The avowed purpose of this innovation, as stated by its proposer, was to do away with "the intrigue and manipulation of market operators who, for their own base ends, bribe the officers in charge of the mines to work the latter in the interests of the market," etc. It must be confessed that the wide divergence in the estimates of ore reserves by different engineers, which has characterized the sensational fluctuations in the share quotations of the Kalgoorlie mines, does justify criticism and warrants thoughtful consideration. On several occasions during the last ten years the share market has been rigged by concerted action between managers and operators, some of whom have been directors; in part, this is explained by the fact that the mine-owners of the boom period have included a large proportion of accidentally rich men of low antecedents. Various coteries have striven in turn to oust each other in order to control the rate of production and sources of information at the mines. Several infamous episodes have disgraced the history of the Kalgoorlie companies, and it has required much good hard work to restore West Australian mines to the position of respectable investments which many of them now occupy.

Of course, the idea of a government inspector, to value the mines as an independent appraiser, is wholly fanciful; the cost of sampling the large mines of one district alone, that is, Kalgoorlie, would run into half a million dollars, as Mr. Hoover said, nor must the element of time be forgotten, it would take a competent engineer at least three years to do the work thoroughly at Kalgoorlie alone, and it is safe to say that such a man would never be able to keep pace with the development taking place even in a few of the largest mines of Western Australia. Moreover, such a man, unless appointed for life, would be the sport of political intrigue, and if his position were safe beyond dismissal his power would be such as it is inadvisable to delegate except under conditions for which there is no other remedy.

But there is another remedy. Let it be recognized that it is as unprofessional for engineers to traffic in mining shares, especially those of mines under their management, as it is for brokers to buy and sell securities for their own account Give up the idea that a man is a better manager by becoming a stockholder; recognize that his judgment becomes vitiated by heavy financial participation, pay him handsomely; not for putting up the price of shares, but for bringing the costs down, and when this has been done, turn round to headquarters and tell the directors that they are wrong when they gamble in the shares of the company whose trustees they are; let them publish all information from the mine promptly and before they use it for their own advantage, let it be beneath a director's dignity to sneak around the corner with a bit of official information before it is formally published, and then, as a final step calculated to lessen the vagaries of ore estimates, elect directors who have had sufficient experience in the business of mining to be capable of choosing competent managers and of supporting them loyally when once chosen. This will be much cheaper than the appointment of the impossible official suggested by the President of the Council of West Australian Mine-owners.

COST PER TON AS A BASIS OF MINE VALUATION

By R. Gilman Brown

(August 29, 1903)

Hardly second in importance to the determination of value per ton, by careful and systematic sampling, is the determination of cost per ton from the mine accounts. The object of sampling has been attained when the gross valuable content of the ore exposed in the mine has been determined. This, for the sake of convenience in subsequent calculation, is usually reduced to value per ton. From this gross value per ton must be deducted the total cost per ton and the loss per ton in treatment, the remainder being the net value per ton. Obviously an error in cost per ton is just as important as an error in gross value per ton, so that it is necessary to examine with as careful scrutiny the method of obtaining the one as of the other. Several pitfalls have been pointed out recently in the columns of this Journal which will be ignored in this present article; or, rather, they are assumed to have been satisfactorily avoided, the desire being not to obscure another factor in valuation which has been touched upon but lightly, if at all.

It is not intended in the present article to go into the details of mine accounting, but it will be assumed that in some way or other the engineer has obtained certain segregated totals representing the expenditure during a certain period in the various operations connected with mining and beneficiating the ore, and that the sum total of these segregated accounts represents the total cost of operations for the period in question.

It is usual to divide these segregated totals by the tons of ore treated during the same period, and to call the quotients the cost per ton for the various departments. In a certain sense the sum of these is a cost per ton, though not properly to be considered *the* cost per ton, as the result is rather a hazy approxima-

tion representing, perhaps, average work for the mine, but not sufficiently definite to be used with confidence in the delicate work of valuing ore reserves.

Let us assume certain natural divisions of the accounts into stoping, development, reduction and general expenses All the segregations can be easily grouped under these headings; and this would naturally be done in the process of arriving at the cost, in the manner to be described In the inexact method commonly employed, these totals would all be divided by the same tonnage—probably by the tonnage reported from the mill or reduction works, whereas, this would give true results only for the last two items, namely, reduction and general expense. For stoping, the result might be approximate except in the case of a mine carrying a considerable amount of ore in the stopes. For development, it could give the true value only when the same amount of ore is stoped as is developed during the period. If development falls behind, the result per ton would be too little; if it exceeds the output, it would be too much.

This is the general statement of the matter, but it can be made clearer by considering a concrete case. It is proper to say that this, though based on practice, has been elaborated, with the assumption of certain values, to suit more general conditions.

The period is 12 months.

Tons treated, 50,000.

Total return per ton, $5.26.

Total loss per ton, 64c.

Total gross value per ton in ore, $5.90.

Herewith are given in tabulated form the costs of the various departments and the costs per ton, as commonly calculated:

	Total.	Per ton basis of tons treated.
Stoping	$58,000	$1 16
Development	50,000	1 00
Deduction	92,000	1 84
General expenses	22,000	44
Total	$222,000	$4.44

The following tonnages are also given:

	Tons
Ore broken in the stopes	10,000
Ore standing, blocked out, ready for breaking	100,000
Ore reasonably expected, but partly, if at all, developed.	50,000
Total	160,000

These are the quantities assumed to be found by the engineer on his investigation of the property, and the recoverable value per ton will be taken at the average of the past year, which we will assume to have been determined to be the fact by careful sampling. The most natural way of calculating the value of these reserves would be as follows.

Total recoverable value of 160,000 tons, at $5 26.	$841,600
Costs on 160,000 tons, at $4 44	710,400
Apparent profit in reserves	$131,200

This is manifestly incorrect. Stoping and development should not be charged against ore already broken, nor should development be charged to that standing blocked out and ready for stoping. The estimate should read as follows, assuming the figures for cost per ton to be correct:

10,000 tons broken in stopes, at $2.28 per ton for milling and general expense	$22,800
100,000 tons developed, ready for stoping, at $3 44 ($2 28+ $1.16).	344,000
50,000 tons, reasonably expected, but not developed, at $4.44.	222,000
Total costs	$588,800
160,000 tons, recoverable value as above	841,600
Net profits	252,800

The cause of the great difference is obvious. It should be noted that in the accounts, transportation and handling costs are assumed to belong in general expenses. The above figures must be taken as thrown in, apart from the fundamental matter with which this article opened, and they contain errors, as was indicated in our opening lines.

Reduction costs and general expense are properly reduced to the per ton basis by dividing by 50,000 tons, but stoping and development cannot properly be so reduced until we know

whether 50,000 properly represents the tons stoped and the tons developed. In what follows we are using some quantities that an engineer examining the property can scarcely have come at directly, and indeed he will be fortunate if he has them at all; but, recognizing their importance, by inquiry and estimate, he must arrive at some sort of a probable value for them.

We have, as a general proposition, that the actual amount of ore broken during the year is equal to the ore on hand broken at the end of the year, plus the ore treated during the year, and minus the ore on hand broken at the beginning of the year. In the same way the ore developed during the year is equal to the ore blocked out at the end of the year, plus the tons of ore broken during the year, and minus the ore standing blocked out at the beginning of the year Applying this to our concrete case, we will assume the following values for tonnage at the beginning of the year:

	Tons.
Broken in the stopes	20,000
Standing blocked out	120,000
Reasonably expected	60,000

Ten thousand tons plus 50,000 minus 20,000 equals 40,000, which turns out to be the actual ore stoped during the year, so that the true cost of stoping per ton is 58,000 divided by 40,000, equals $1.45 per ton. In the same way 100,000 plus 40,000 minus 120,000 equals 20,000 tons, the actual ore developed during the year; and $50,000, the total spent on the development, divided by 20,000 tons, equals $2 50 per ton, the true cost of developing a ton of ore. Inasmuch as no costs are credited in this discussion to the ore reasonably expected, we need not carry this further, though the same reasoning would hold in regard to it. Collecting our true cost per ton, we have:

Stoping	$1.45
Development	2 50
Reduction	1 84
General expense	.44
Giving the true total cost per ton at	$6 23

This shows that the ore at this mine will not actually pay expenses for handling unless greater economies can be practiced; whereas, our first calculation gave a profit per ton of about 80c.

To a certain extent, then, the matter concerns the mine manager as well as the examining engineer, though it is in the interest of the latter in particular that this article was prepared

Proceeding next with the valuation of ore reserves, we reproduce our earlier figures with the corrected costs introduced:

10,000 tons, broken, at $2.28 per ton	$22,800
100,000 tons, developed, ready for breaking, at $3.73 ($2 28+$1 45) per ton	373,000
50,000 tons ore, reasonably expected, at $2.23 .	311,500
Total . . .	$707,300
Recoverable value, as above . .	841,600
Net value on the reserves .	134,300

In order to lay the whole matter more clearly open and even at the risk of being tedious, it is worth our while to make another assumption regarding tonnages at the beginning of the period, as below.

	Tons
Broken in the stopes . . .	None.
Standing ready for breaking .	80,000

The tonnage and cost per ton follow in summary:

	Tonnage for year	Cost per ton.
Stoping . . .	60,000	$0 97
Development	80,000	0 62
Reduction and general expense, as before.	50,000	2.28
Total .	. .	$3 87

On this basis, the value of the ore reserves is.

10,000 tons, broken in stopes, as before	$22,800
100,000 tons, ready for stoping, at $3 25 ($2 28+97c) per ton .	325,000
50,000 tons ore, reasonably to be expected, at $3 87..	193,500
Total charges . . .	$541,300
The gross recoverable value, as before.	841,600
Profits in reserves . . .	300,300

The differences shown clinch the statement with which this paper opened.

As a summary of the above there are two general principles to be enunciated:

(A) Cost per ton is the quotient of total cost divided by the actual tonnage resulting from that expenditure

(B) Net value per ton is the gross recoverable value per ton, less cost per ton for those natural divisions of the work still to be performed upon the different classes of ore.

Although the above principles are fundamental, like all general statements they may easily be pressed to extremes, and it is for the engineer, after analysis of the situation, to decide the particular extent of their application; a failure to recognize them at all, on the other hand, may invalidate the conclusions drawn from otherwise reliable work.

MINE ACCOUNTS

(August 29, 1903)

The Editor:

SIR—The concise and creamy presentation of the important subject of gold mine accounts by Mr. H. C. Hoover in a recent number of the JOURNAL[1] leaves me little chance to get a good hold. But the necessity for discussion of an issue of such vital moment to the mining industry leads me to venture some contribution at this juncture.

Mr. Hoover does yeoman service by shutting off at the outset the puerile plea of diverse conditions, which has too often been the excuse for such woeful chaos as greets the investigator when he begins to attempt the arranging of actual methods into some show of system. The difficulties in the way of uniformity lie mainly in theory and not in practice, arising not from varying conditions, so much as from lack of method or of clean-cut ideas concerning the ends to be sought in systems of account. I presume that many engineers will smile at this statement, at first glance, because there can be no serious difference of opinion among well trained members of the profession as to what ought to be shown by the books. But, unfortunately, the enforced examination of the accounts of many companies proves to the writer the very inadequate manner in which the expected information is obtainable, save in exceptional instances.

Mr. Hoover lays down three methods, or principles, which should govern a proper system of accounts. In my own practice, I have always recommended such measures as would ensure these same results, but, perhaps, from an attitude not exactly similar.

1. "*To prevent fraud * * * and to carry conviction of honesty.*" This practically requires the keeping of all records and the summarizing of the same in such manner as to ensure adequate checking of one officer by another. This not only guards against fraudulent intent, but it also protects servants by veri-

[1] Page 44, July 11, 1903.

fying their records before the opportunity to correct possible errors has passed

2 "*To show expenditure * * * on some unit basis, etc.*" This important end can be accomplished only by the most detailed accumulation of data from all sources, and this is the direction in which looseness is most commonly discerned. Discrepancies arise not so much from misconception or differences of opinion on methods of segregation, as from inability to comprehend the correct principles underlying mine accounts.

3. "*To be presented in such a way that the owner, director, shareholder, or what not, may * * * determine something of the efficiency of the manager himself.*" Here is a subject which demands careful handling. The best system of accounts for a given business is one capable of yielding minute cost analyses at the hand of an expert, but at the same time adapted to comprehensive summarizing for home office use. Some companies sacrifice everything else to fancied economy, by gathering only totals in the accountant's books, thus rendering very difficult the task of analyzing costs. On the other hand, not a few accumulate details in such heterogeneous fashion as to make it impossible to readily obtain grouped footings when required.

The British system, if we may properly apply this term to anything at all, has, I think, developed a morbid tendency to extreme simplification of the general ledger accounts. Mr. Nicol Brown has finally evolved a plan by which four main accounts, with chiefly annual or monthly entries, carry nearly all of the business, in lump But this necessitates a voluminous and complicated system of schedules to be made up from departmental reports, and in many respects the scheme is more cumbersome than is acceptable to American usage.

In Mexico, a plan devised for the Compañia Metallurgica and in use elsewhere in that country in more or less modified form, has features which overcome some of the objections to the British style. The principle is to carry on the general ledger a moderate number of prominent accounts, to which totals are posted from journal and cash book, using a subsidiary ledger to take up itemized segregations which may be specialized to any extent deemed desirable. With this system, the accounts are numbered serially and all employees concerned are provided with printed books, giving the complete classification by numbers and titles. In

adapting it for use in one instance, we have arranged the general ledger to furnish information ordinarily liable to be required by the home office, which receives the monthly trial balance A quarterly report of audit of the books also goes to the home office, with an analysis of costs, made independently by the consulting engineer. The subsidiary ledger furnishes the material at once for such analysis. But the important point with this, as with any system of accounts, is the manner in which the records are kept and assembled for entry in the accountant's books.

I do not know that it is fair to talk of an American system of mine accounts, only we may note the trend of practice in the United States to be toward labor-saving devices in book-keeping. The standard card systems, filing cases and automatic devices are mostly flexible and well adapted to the gathering of data and their preservation in convenient form for study. But comparatively little has thus far been done towards applying these aids in mine accounts. The writer has used such appliances for several years, under a variety of conditions, and always with success. The real work consists in preparing the forms. After that the system almost works itself, and even prejudiced persons soon come to esteem the method and to operate it with keen satisfaction.

If it be possible to formulate a standard system of accounts adaptable to all needs and so planned as to give comparable results as between different operators I take it that some agreement must be reached regarding a number of points on which practice now differs. These matters once adjusted, it would be wise to prepare a skeleton, which, on broad lines, should be very simple and comprehensive in its segregations. Each main division ought then to be divided and sub-divided to give operators free choice of subsidiary accounts.

What are known as "Capital accounts" over sea, as distinct from cost and revenue (profit and loss) accounts, have not been as clearly defined in American practice. This is due (1) to differences in tax collectors' methods, which, on this side, are variable and rarely introspective; (2) to the difference in attitude of home and foreign investors; (3) to different methods of stock distribution here and there, and (4) to rigid auditing abroad and the sad lack of it at home. These items, however, need only be stated as causes historical, and not as *raisons d'être* in the premises. Moreover, Mr. Hoover appears to have found his discordant

elements largely in a country which is supposed to set the pace for us to follow, for there is no doubt that the British ideals are beyond and above us in their appreciation of the value of accounts. Once let the spirit move us to "get together" in the matter, I venture the prediction that we will evolve a system less cumbersome and unwieldy to accomplish the end in view

Duly crediting Mr. Hoover with the original suggestions that the Institute of Mining and Metallurgy and the American Institute of Mining Engineers appoint a joint committee to formulate some plan of working cost statements, after discussion of the subject, I would venture to suggest a modified proposition, as follows: Let the Institute of Mining and Metallurgy and the Institution of Mining Engineers appoint a joint committee of ten (five from each organization) to act as a British sub-committee to correspond and collect qualified opinions from their membership, and to classify the same, with recommendations. Let the American Institute of Mining Engineers appoint a similar committee of ten to act independently on this side in the same manner and with a similar purpose. After a given period of deliberation, let each committee of ten select from its own membership two persons to form a new committee of four, to be charged with the duty of developing a plan from the final reports of the larger committees. Meanwhile, the free discussion of the subject in all its bearings need not be restricted in any degree.

I respectfully submit this first draft of a plan which may well be modified in detail by wiser heads. The principle of the idea is one which might also be applied to many other topics of interest; and the fact that many mining engineers are now enrolled in the respective institutions on both shores suggests the propriety of establishing one or more joint standing-committees on general issues.

In the United States we have not been accustomed to draw the somewhat arbitrary distinction which is made abroad between "gold mine accounts" and mine accounts in general. The former require in reality but the simple framework about which may be built up the more complicated systems rendered necessary by products requiring amplified processes. But, if the necessity exists for standard specifications in the one case, so much the

more are they called for in the business of mining and treating complex ores.

The differences in modes of writing up particular items, as mining development, etc., with other variations in practice mentioned by Mr. Hoover, also the questions raised by your London correspondent, in an article in the same issue of the JOURNAL,[1] all serve to show the present lack of uniformity in method. To some extent, it may be feared that corresponding discrepancies in purpose may also be discernible. I can only add at this writing that my own practice has encountered somewhat equivalent diversity of need in varying circumstances. But the general plan which covers the systems adopted is susceptible of adjustment to these several requirements, and the books of any corporation using the method will yield cost analyses of a typical form, however much the details may thus be modified. Whether the particular type form is the best for all uses, and how nearly this plan will approximate the standard to be finally adopted, are very open questions. It is to be hoped that the whole subject will be amply discussed with a view to the eventual adoption of definite standards by the profession at large.

THEO. B. COMSTOCK.

Los Angeles, Cal., August 14, 1903.

[1] "The Payment of Extensions of Mining Plant Out of Revenue," by E. Walker, this JOURNAL, p. 48, July 11, 1903.

ORE-BREAKING AND SORTING ON THE RAND*

BY H S. DENNY

(September 19, 1903)

IN all the mines on the Rand the ore before being sent to the surface is regulated to a certain maximum gauge by an arrangement of sizing bars fixed over the station bins at the shafts. The object, primarily, is to reduce the largest pieces of ore to such a gauge that there will be no liability to choke the outlet from the bin; but it serves also the secondary and equally important purpose of preventing rocks of too great a size from passing to the ore-sorting house.

The ore when delivered at the surface is usually classified into "fine" and "coarse rock" by dumping the skipload onto a grizzly in the headgear; the fine, being unsortable, goes direct to the mill, and the coarse ore is sent to the sorting house.

The rock in the sorting house is subjected to scrutiny either on floors, revolving tables or traveling belts, and the rejected waste goes to the dump. The sorted ore is fed into ore-breakers for further reduction.

The breakers may be classified into two generic types, the gyratory and the crank motion type, the former being largely represented by the Gates and the latter by the Blake machine. Each type has its supporters, but it is generally considered by the moderates that the former is the better machine when unit capacity is demanded, and the latter when multiplication of machines is not embarrassing to the general design, as its maintenance cost is less.

The general scope of the rock-breaker is to reduce the ore to about a 2-in. cube before delivering to the mill, but the average

* Abstract from advance sheets of paper entitled "Observations on the Metallurgical Practice of the Witwatersrand," by H. S. Denny, read before the Chemical, Metallurgical and Mining Society of South Africa.

in the mill-bins will be found to exceed this gauge, owing to wear in the crushing part of the breakers. In the most recent practice it is recognized that there is an advantage gained by subjecting the ore to a preliminary breaking; that is, to reduce its size before passing it to the sorting house in order that there may be closer uniformity in the sizes of the pieces of ore that are subjected to the sorting operation.

It is, I think, doubtful whether the practice of ore reduction in breakers is carried sufficiently far. It would appear that a material increase might be obtained in the stamp duty if there were a succession of, say, three breakers, each reducing the ore to smaller gauge than the last, until the final product did not exceed an average of, say, half-inch cubes.

The line of demarkation defining the point where ordinary breaking should cease and milling begin, has never yet been accurately determined, and this limit should be ascertained by actual experiment.

Recently there has been much discussion regarding the question of sorting, and in some particular cases where sorting has been practiced hitherto it has been decided to abandon the operation, as it is claimed that more favorable results can be obtained without it. There are many aspects of this question which lend themselves to conflicting conclusions, but that there are some cases in which the operation is highly beneficial, there can be no doubt. To say that sorting is an operation that should apply to every proposal is, in substance, to claim that the same conditions are presented in each case. This we know is not so, and, consequently, the operation will more particularly apply to one case than to another, and there will be limits at which it will reach its highest efficiency and its lowest.

I propose to take a case representative of certainly the majority of the mines on the Witwatersrand, and will deal with it both on a sorting and a non-sorting basis.

Assume that we have a mill of 100 stamps, a property of 100 claims and 40,000 tons per claim. The total tonnage would be 4,000,000 tons. Suppose each ton of ore delivered at surface to have the following value: 50 per cent fine, 12 dwt. per ton; 50 per cent coarse rock, 12 dwt.; 100 tons contain 1,200 dwt., worth, at $1.008 per dwt., $1,209.60, equal to $12.096 per ton. Without sorting we get, say, 80 per cent extraction, equal to $967.68, from

100 tons; that is, \$9.676 per ton. Assume costs at \$5.76 per ton, divided as follows:[1]

Mining	\$2 52	per ton milled	(15,000	tons)		\$37,800
Crushing	0 12	"	"	"		1,800
Milling	0 60	"	"	"		9,000
Cyaniding	0 60	"	"	"		9,000
Slime handling	0 12	"	"	"		1,800
General	0 72	"	"	"		10,800
Head office	0 36	"	"	"		5,400
Mine-development redemption	0 72	"	"	"		10,800
	\$5 76					\$86,400

Leaving a profit of \$3.916.

One hundred heavy stamps crush 500 tons per day, or 15,000 tons per month, equal to 180,000 tons per annum. Life of mine equal to 22.2 years. The net profit made in that period is 4,000,000 tons at \$3.916 per ton, equal to \$15,664,000. The present value of that amount at 5 per cent compound interest is \$5,470,663.73. (In this calculation I have not allowed for amortization of capital.)

With 20 per cent sorting we have the following statement: 50 tons fine at 12 dwt., equal to 600 dwt. From the remaining 50 tons, containing 600 dwt., we discard 20 tons carrying 2 dwt, equal to 40 dwt., leaving 560 dwt. contained in 30 remaining tons. We thus have 80 tons of ore containing 600 plus 560, equal to 1,160 dwt., equal to, at \$1.008 per dwt., \$1,169.28, equal to \$14.616 per ton; 80 per cent extraction equal to \$11.694 per ton.

The costs in this case would be as follows:

Mining	\$3.15	per ton milled	(15,000	tons)		\$47,250
Crushing	0.12	"	"	"		1,800
Sorting	0 12	"	"	"		1,800
Milling	0 60	"	"	"		9,000
Cyaniding	0.60	"	"	"		9,000
Slime handling	0 12	"	"	"		1,800
General	0 84	"	"	"		12,600
Head office	0.48	"	"	"		7,200
Mine-development redemption	0 90	"	"	"		13,500
	\$6.93					\$103,950

It might be argued that mining costs should be taken lower in this case as against the first, seeing that the fair proportion of general charges is spread over the larger tonnage mined. The state-

[1] In these calculations the £1 sterling is taken at \$4.80; 1 shilling at 24 cents.

ment would leave a profit of $4.764 per ton milled; 18,750 tons per month, equal to 225,000 tons per annum; life of mine equal to 17.7 years; tons milled equal to 3,200,000, at $4.764 per ton, net profit equal to $15,244,800 earned in 17.7 years. The present value of that amount is $6,429,644, or a difference in favor of sorting of $958,980. In this comparison we have the same sized plant milling the product of 18,750 tons mined in the one case as against 15,000 tons in the other.

Against the extra cost of mining to produce 15,000 tons for the mill when sorting, we have the extra cost of milling, handling and treating the extra sand and slime which we should have to incur without sorting. It must not be forgotten, too, that in the case of non-sorting, every ton of waste rock has to be provided with 10 tons of water, and the cost of up-keep and cleaning out of slime pits will be increased by reason of the extra tonnage. I have assumed the cost of milling to be the same in both cases. The only extra capital expenditure for the case in which we adopt sorting, is the sorting plant. It has been argued that, if the mill capacity were increased to an extent sufficient to cope with the extra tonnage, this would be more economical than sorting.

Taking the cases above cited, we must increase to 3,750 tons more; as one stamp will crush 150 tons per month, this is equal to 25 stamps more. With the increased tonnage working costs might be reduced to, say, $5.28; but a corresponding increase in the mill when sorting would also show reduced working costs, and therefore the comparison would only increase the favorable aspect for sorting.

The rock discarded I have estimated at 2 dwt. in value, $2.016 per ton. We get 80 per cent extraction from this, equal to $1.613. It has to be crushed, 12c.; milled, 60c.; cyanided, 60c.; converted into slime and handled, 12c.; total $1.44; and the margin in profit would not cover its share in depreciation of plant and the loss of water involved, while at the same time it is preventing the treatment of more valuable ore if sorted; and all this, too, on the assumption that its corresponding residue would only be 0.4 dwt., and nothing in the slime, whereas, it is probable that the sand residue and the slime from it would be the same as the rest of the ore, and, therefore, more than 0.4 pennyweight.

I am presupposing in these illustrations that 20 per cent sorting is not only possible, but easy of actual fulfillment. There are,

however, many variations in the cases to which sorting is applied, and each case must be judged on its individual merits. These variations may be expressed as lying mainly in the factor of reef thickness.

For instance, on a reef 3 in thick, where the stopes average, say, 42 in., the reef matter in every ton of ore mined is only 7 per cent, and, assuming that we have 50 tons of fine, containing 3½ tons of reef, we have 50 tons of coarse rock containing the same proportion. In such instances it might be possible to sort 40 tons of waste rock in every 100 tons from the mine.

On the other hand, we may have 12 ft. of reef matter, of which we mine, say, the central 8 ft, and as the whole of our product would be reef, no sorting would be possible.

These are two extreme cases, and between their limits will occur the variations between nothing and 50 per cent sorting.

I have thus far assumed 50 per cent as representing the average percentage of fine in ore from the mine, but naturally there are important variations in this factor dependent directly on:

(1) Setting of grizzly bars.
(2) Method of stoping.
(3) Nature of ground.

If machines are used exclusively for stoping, the percentage of the fine will be high, while if hand labor only is used the percentage will be low On many mines a combination of the two is resorted to; 30 per cent, however, represents about the minimum and 60 per cent the maximum, and something between the two, say 40 to 50 per cent, will be the average.

With 50 per cent fine it is necessary to carry out an actual 50 per cent table-sorting to represent 25 per cent on the tonnage mined.

On the above showing it is clear that, where it is possible to sort out waste rock of an average value of 2 dwt., it is a highly profitable proceeding. It is possible, however, to sort too little or too much. On a 3-in. reef, with a 4-ft. stope and 40 per cent fine, 20 per cent sorting would be far too low, while on 3-ft reefs and 4-ft. stopes, allowing 50 per cent fine, 20 per cent would be far too high, and the average value of the discarded rock would reflect this.

Each case must, as before stated, be figured out on the par-

ticular circumstances regarding reef and stope thicknesses which obtain.

In some cases on the Witwatersrand I have heard it argued that the quartzites immediately overlying or underlying the reef carry sufficient gold to make their treatment profitable, but I have not met any such cases personally, excepting in some isolated sections, where the occurrence is too limited to influence the general question.

Naturally the object of sorting is to discard rock which cannot be treated profitably, and if the value of the waste rock at any time exceeds this limiting factor, then the operation is done at a loss That limit will vary according to conditions, and must be computed independently for each proposition.

It is not an easy matter to arrive at the value of waste rock I know of no method of sampling in vogue to-day which could be called accurate. The best check on the work is the recovery set against the value in the mine, and the discretion of the manager must be relied upon to see that there is a proper correspondence between these two points

There are methods which suggest themselves certainly, and of these, either of the two following might be adopted.

(1) A certain percentage, or even the whole of the waste rock coming from the sorting plant, to be passed through a set of two or more breakers and reduced fine enough to be sampled. Samples to be taken constantly over a period of one month and the operation to be repeated every few months.

(2) Five or 10 stamps to be occasionally set aside entirely for waste rock, and the crushed product to be treated independently of the ore passing through the remainder of the mill.

Of these two alternatives the first is the more feasible, although the second is undoubtedly the more accurate, but the expense attaching to the latter method prohibits it. If a mine is not in a position to keep its full mill going, it might use some of the idle stamps for this purpose, and instead of treating the resultant pulp separately, simply take a careful series of screen samples.

Another point (which has arisen and which bears very directly on our present condition wherein, owing to shortage of labor, we are, in some cases, able to mine only sufficient ore to feed a portion of our battery) is whether it is not of greater advantage

to run the whole mill on unsorted ore than to adopt sorting and keep stamps lying idle.

Take the case of a mine equipped with 100 stamps, where only 500 tons of ore can be milled per day. If 25 per cent sorting is adopted only 75 stamps can be run, whereas without sorting the full mill could be kept running.

Assume the ore consists of 50 per cent coarse rock and 50 per cent fine, and is worth, delivered at surface, 14 dwt., and that we secure 80 per cent recovery in either case, and that the waste rock discarded in the case of sorting is 2 dwt., we then have the following comparative statement.

Case for Sorting—

100 stamps will crush 500 tons of ore per day	
250 tons fine at 14 dwt	3,500 dwt.
125 tons sorted ore at 26 dwt	3,250 dwt.
Total 375 tons of ore at 18 dwt	6,750 dwt

Eighty per cent of 18 dwt. amounts to 14.4 dwt. at $1.008, equal to $14.515 recovery.

Expenditure—

Mining	$3.36	per ton milled (375 tons)	$1,260
Crushing	0 12	" " "	45
Sorting	0 12	" " "	45
Milling	0.60	" " "	225
Cyaniding	0.60	" " "	225
Slime handling	0 12	" " "	45
General	0.84	" " "	315
Head office	0.48	" " "	180
Mine-development redemption	0 96	" " "	360
	$7.20		$2,700

Profit $7.315 per ton, equal to $2,743,125.

Case for Non-Sorting—

Five hundred tons at 14 dwt. equal to 7,000 dwt., 80 per cent of 14 dwt. equal to 11.2 dwt. at $1.008, equal to $11.289 per ton.

Expenditure—

Mining	$2.52	per ton milled (500 tons)	$1,260
Crushing	0.12	" " "	60
Milling	0.60	" " "	300
Cyaniding	0.60	" " "	300
Slime handling	0 12	" " "	60
General	0.72	" " "	360
Head office	0 36	" " "	180
Mine-development redemption	0.72	" " "	360
	$5.76		$2,880

Profit $5.529 per ton; 500 tons at $5.529 equal to $2,764.50. Difference in favor of non-sorting, $21.375.

In the latter case, however, there is an extra charge for loss of water and for depreciation of the extra stamps to be run, and if these allowances be made there is in the comparison above made remarkably little difference.

The whole issue hinges finally on the value of the rock discarded. If that value is only 1 dwt., then sorting will prove advantageous, but if we allow 3 dwt. for the waste rock, then it would pay to run the idle stamps, and it is on the determination of this factor that the policy adopted must be guided.

This comparison must in no way be confused, however, with the question raised in the first illustration in which the tonnages crushed are equal.

MINING INVESTMENT

(Editorial, September 26, 1903)

Our friend Mr. J H. Curle has been writing a series of useful articles in the London *Economist*; his utterances have been couched in very plain language, and have conveyed a large measure of unadorned fact intended obviously to puncture some of the filmy sophistries which obscure the business of mining. Finally, at some one's suggestion, he has given the readers of *The Economist* a dose of advice which summarizes a good deal of what he has previously said. With the general tenor of these *obiter dicta* we do not quarrel; on the contrary, we welcome the introduction of so much good sense into mining matters, and congratulate the author on the excellent results likely to accrue from his outspoken ratiocinations. However, as we ourselves live in a country where mining is still young and hopeful, with some of the exaggerations of youth but with all of its vigor, we take exception to certain of his conclusions. The latter undoubtedly suffer from brevity; unqualified generalizations are rarely impregnable, and in this case they are obviously endangered by the enormous range of conditions covered by the mining regions of the world. Mr. Curle says: "Don't invest in copper, tin or silver-lead mines, but stick to gold mines." Of course, this advice is intended not for mining operators or well-informed people, but for the average investor, who, like an innocent child, is supposed to wade on the edge of the sea of financial speculation. "Gold has a fixed value," he goes on to say, "whereas violent fluctuations in the prices of other metals upset all estimates of the earning capacity of the mines producing them." Why, then, should one not avoid risk of any kind and buy Consols or United States bonds, or conservative bank stock or debentures of the most gilt-edged variety? Why? Simply because people who go into mining do so because they want a bigger return for their money and expect to get the benefit of a speculative enhancement of their principal. Bring mining to the strictly investment basis of which Mr. Curle writes so much, and it shrivels to feeble dimen-

sions indeed. The investor who wants to eliminate all risk in mining is like a man who expects to go bathing without getting wet Such ideas entirely misinterpret the spirit of legitimate mining. What shareholder, we would ask, wants to forego entirely all the possibility of favorable development or of new discovery? It is the chance of enhancing the value of his holding which gives zest to the business of mining. Such possibility of further discovery entails inevitably the equal possibility of disappointment; the uncertainty cannot be all in one direction. In other words, the mining investor only asks that he may get "a run for his money." In Cornwall shareholders are known as "adventurers," not with the modern meaning of irresponsible schemers, but with the old Elizabethan idea of men who go on a venture, take a reasonable risk, and are hopeful of a favorable return.

Mr. Curle has expressed great respect for the good sense of American engineers and mine operators; we feel safe in saying that these men heartily disagree with any such sweeping statements as the foregoing in regard to mines producing metals other than gold. Of course, when the product of a mine is liable to fluctuation in market value, the purchaser of it, or the stockholder, will expect a larger dividend to compensate for the added risk. Markets vary; even the purchasing power of gold is not constant; but the conclusion is not to try to get rid entirely of an essential factor—risk—but to require a proportionate return in the rate of interest. There are many of our readers, we feel assured, who, if asked to choose between a gold mine yielding a small rate of interest with but little risk (such is the mine Mr. Curle recommends) and a silver-lead, copper or tin mine with a larger risk but with a bigger return for their money, will select the latter. The idea that all gold mines must have 60 per cent of their market valuation represented by net profit on ore in reserve and must yield 10 per cent on their investment price is the dream of a doctrinaire. A few such mines are quoted on the exchanges, and they exist just now mainly by reason of a busted bull market and an unusual condition of financial depression. When better times return, even these shares will rise to a figure at which they will cease to fulfill the requirements which Mr. Curle exacts; and then the economist of *The Economist* will have a theory with visible means of support.

A CARD SYSTEM FOR MINE ACCOUNTS *

BY F. W DENTON

(September 26, 1903)

SINCE the first of the present year a card system has been in use at the Baltic copper mine in connection with the general supply account. The system has proved satisfactory. Two sets of cards are employed. One set is retained in the supply clerk's office and is kept up to date by him, and the other set is kept in the main office and is written up by the office clerks. The cards are 3 by 5 in. and 5 by 8 in. respectively, and are ruled as shown. The difference between the two sets is as follows: On the supply clerk's card, Fig. 1, only the date, balance on hand, quantity received, and quantity used are recorded, while on the office card, Fig. 2, all of these appear, and in addition the initials of the firm supplying the goods, cost, value of amounts consumed and the accounts to which the supplies are charged.

The method of using the cards is as follows: When the duplicate bills for supplies are received one copy is sent to the supply clerk, who checks the bill and enters the quantities on his cards. As supplies are issued during the month a memorandum is made in an ordinary book in the usual manner. At the end of the month the supply clerk prepares from his memorandum book two reports, one of which is arranged according to the expense accounts and the other according to the kind of supplies. That is, on one report under each expense account will be put all of the supplies charged against that account for the month, and on the other report, under the name and size of each article, will be given the total consumption of that article. This last mentioned special report assists the office force in writing up the office cards. These reports are turned over to the general office.

* Paper read before the Lake Superior Mining Institute, August 1903

At the end of each month, when all of the supply bills have been received and checked, the office clerks enter the quantities and costs on the proper cards and compute a new average price if necessary. This average price may be computed as closely as desired.

As soon as the pay-roll is finished at the first of the following month, before which time the supply clerk will have sent in his two reports, the office force takes the report of the supply clerk and completes the entries on the office cards. The special report of the supply clerk, showing the total amount issued of each kind of supplies, is used to check the work of picking out the individual records from the detailed report arranged by accounts, and insures all entries being made on each card at the same time. When the entries are finished on a card, and before returning the card to the drawer, the respective quantities used during the month are multiplied by the average price and the amounts entered in the proper column on the card, and also in the proper place in the supply clerk's report. The balances of quantity and value are then brought down on the card, and the work on that card is finished. By copying the total value of supplies consumed from the cards to the supply clerk's special report and afterward checking the footing of this report with that of the detailed report, a good check on all the clerical work but the multiplication is obtained, and the average price checks that near enough.

The values having been obtained in this way for the supply clerk's report, the main function of the card ceases as far as the mine books are concerned, and the supply clerk's report is then used in the usual manner. If any allowance is to be made for freight and other expense connected with supplies not covered by the original supply bills, such allowance can be made by adding a certain percentage to the footing on the supply clerk's report.

At the Baltic the supply account on the ledger will in future be charged with the amounts of the supply bills only, and credited with the amounts as figured from the cards.

The cost of handling supplies to and from warehouses, the cost of heating and lighting these buildings, and any other expense connected with the caring for supplies, are all charged off each month as they occur to one of the general expense accounts

under the name of caring for supplies. The freight bills paid each month for supplies are charged off the same month to the various expense accounts in proportion to the values of the supplies used by these accounts. This method of handling freight and other expense connected with supplies is as fair as any other in general use, and has the following advantages: First, the balance shown by the supply account on the ledger should check with the balance shown by the cards; second, by keeping the expense of caring for supplies by itself, this expense stands forth conspicuously each month and can be looked after the same as any other operating expense.

The time required to write up the cards is not as much as one might suppose. At the Baltic 48 air drills are in operation and about 750 men are employed. On June 1 there were in use 871 cards of each kind, and the value of the supplies on hand shown by the cards was about $28,000, which does not include fuel. The monthly consumption of supplies covered by the cards is about $8,500. With this amount of business our office force consists of a chief clerk, one assistant, one timekeeper and one supply clerk. It takes the clerk and his assistant about 1½ days to write up the cards after the supply clerk's reports are received. As previously stated, the data taken from bills are copied on the cards at the end of the month when the office work is lightest.

What are the advantages of the card system? Under our old method the supply account was charged with all expense connected with the supplies, and then 10 per cent was added to a price list to insure a balance on the safe side of the account. The list of prices could not be kept correct, because prices change, and the average price of the stock on hand was not known; therefore, the prices were seldom right, and the 10 per cent addition to this approximate price only served to insure charging off enough.

When the time came for taking an inventory these prices would be put on the list turned in to the office, and if the total value was sufficient to balance the account, everything was considered satisfactory. Generally there was a surplus, but just where it came in was not known. If there was a deficit, another round of warehouses and surface would be made and each trip would result in finding something that had been omitted from the original inventory. These finds might balance the account.

ARTICLE 1½ -in. Black Pipe. 1903.

DATE	BAL.	REC'D	USED	DATE	BAL.	REC'D	USED	DATE	BAL.	REC'D	USED
1 — 1	Ft 1066		655								
2 — 1	*411*										
2 — 9		509									
2 — 21		1045½	613½								
3 — 1	*1352*		830								
4 — 1	*522*		430								
5 — 1	*92*										
4 — 24		2090	220								
6 — 1	*1962*										
	(Figures in italics represent red ink figures in the pen copy)										

8 1500

FIG. I.

If they did not, then the deficit would be charged off and another year started without knowing just where the deficit occurred. Under the card system the balance that should be on hand is shown on the first of each month and this can readily be checked, in most cases by inspection, if desired. In any event, the cards check the consumption, because, when a requisition is put in for more of a given article, the cards should show the stock of that particular article to be used up or nearly so.

By entering the exact bill-cost on the office cards and computing the average price each month if necessary, the supplies are charged off at exactly the proper price.

With certain supplies which are bought in bulk and issued in small quantities that are not accurately measured, such as waste, oil, etc., the quantity reported as consumed can be increased, and the price kept the same and chances of a deficit avoided. By charging only the bill cost to the supply account, the balance as shown by the cards should check with the balance shown by the account. When the inventory is taken it is only necessary to determine whether the balances called for by the cards are on hand. If there is any deficit or surplus it is known just where it occurs, and the trouble can be located at once and a remedy applied. By this method the exact cost per ton for supplies is known from month to month, and the average for the year should not be affected by any surplus or deficit.

In addition to these advantages there are other important ones, especially where the purchasing is done at the mines. It can readily be seen that from time to time as supplies are purchased it is easy to run over the cards and make up an order covering a sufficient quantity of supplies to offer an inducement to dealers to figure close. Then, too, by studying the consumption of supplies as shown by the cards, it is often possible to simplify the stock carried, getting rid of some sizes or adopting certain standards.

In conclusion, I wish to state that the successful introduction of this system at the Baltic mine has been due largely to the capacity and energy of the chief clerk, Mr. William C. Cole.

ARTICLE 1½-in Black Pipe 1903

DATE	BAL.	REC'D	FROM	COST	USED	VALUE	ACCT.	DATE	BAL	REC D	FROM	COST	USED	VALUE	ACCT
1—1	Ft. 1056	@	*10c*	106 60	610	51	M E.								
					60	6	C &D								
					35	3 50	H								
					50	6 00	Cons.								
					655	*65 50*									
2—1	*411*			*41 12*	505	47 98	M E								
2—9		500	I.E S	48 10	108	10 26	C.&D								
2—21		1045½		98 79											
					613½	*58 24*									
3—1	*1352*	@	*9 6c*	*120 75*	570	54 72	M E								
					260	24 96	Cons.								
					830	*79 68*									
4—1	*522*	@	*9 6c*	*50 07*	92	8 83	M.E								
					70	6 72	C &D								
					268	25 69	Cons.								
					130	*41 24*									
5—1	*92*			*8 83*	60	4 80	H E								
4—24		2090	P.L Hd.	165 96	160	12 80	S R								
					220	*17 60*									
6—1	*1962*	@	*8c*	*157 19*											

(Figures in italics represent red ink figures in the pen copy.)

FIG. II.

3 1809

INVESTMENT IN MINES

(Editorial, October 3, 1903)

In our last issue we discussed the general advice on mining investments which has appeared in the London *Economist* from the pen of Mr. J. H. Curle, the Special Mining Commissioner of that most excellent financial chronicle. Mr. Curle himself has done excellent service in clearing away cobwebs from the business of mining, so that his ideas come as from one having authority and not as the scribes of the daily press. Nevertheless, we think some of his sweeping conclusions go beyond the mark; for instance, the dictum that "there is only one correct way to value a mine—that is by its ore reserves. Any other basis of valuation is wrong." As an antidote to the twaddle of descriptive matter which used to form the larger portion of mine reports not many years ago such a statement as the foregoing is distinctly bracing, but Mr. Curle is giving his patient, that is, his client, a corrective which will produce spasms if taken without dilution.

We are all agreed, all of us who want to see mining conducted upon the principles of sound business, that the determination of ore reserves is fundamental, and that the amount, value and profit to be derived from such reserves must be the basis of any appraisal of a mining property—but that is not the whole story, by a great deal. One mine may have $500,000 of ore in reserve with a net profit of $300,000, while another may have only $200,000 gross, with $100,000 net profit assured, and yet the latter may be worth more than the former. One mine may be like a man of advanced years with a fine record of achievement and great capacities apparently unimpaired, but still with the certainty of a proximate cessation to his activities, while another mine may be comparable to a young man with not much to speak of in the way of work done, but with great powers and the promise of a fine career. We remember a mine which was carefully surveyed and sampled, with the result that it showed ore which would

yield $456,000 net profit, but most of the headings were poor and the ore bodies were evidently erratic; such a property was worth no more than the net value of the ore, if it were worth as much, the interest on the money invested during the period required to take out the ore reserves being balanced against the slight chances of further successful development. Another mine with $80,000 of profit assured was sold for $250,000 cash, and subsequently made three men millionaires. Of course, Mr. Curle is addressing English investors in mining stocks and not expectant purchasers of mining property; nevertheless, the same considerations hold good. We might instance the Tomboy mine, situated in Colorado, but owned largely by British investors. That mine was bought mainly on the fine showing made by ore reserves which were over-rated and, as a consequence, it proved a disappointing investment; beyond the original ore blocked out at the time of purchase very little more was ever opened up. Subsequently, thanks to an energetic manager and a capable directorate, the company purchased an adjoining young mine, practically a prospect, which, though secured for a fraction of the sum paid for the original Tomboy mine, has since turned out a much more valuable property. It is a fact that the Tomboy shares were worth more on the purchase of a prospect than on the acquisition of a well-developed large mine.

Ore reserves are not everything; expansion and development are of the essence of successful mining. It has been pointed out in these columns that a mining property may be ruined by having too much ore-bearing ground opened up, for the cost of keeping the levels open, draining extensive openings and renewing the timbering may represent a high rate of interest on the capital lying dormant in the ore reserves. This refers particularly to iron and coal properties, but it may very well apply to large low-grade gold deposits such as those of the Rand or mines belonging to the class of the Homestake and Alaska Treadwell. In other words, it is not profitable to open up ore reserves much in excess of the tonnage equivalent to the output for a certain time. That period may be determined by the expense of maintenance, as already described, and the character of the ore deposits; if these are erratic or sporadic, it is obviously necessary to "give hostages to fortune" and ensure regularity of production by averaging a large number of discoveries and stopes of varying tenor.

Mining would not engage the energies and interest of so many if it were but a question of running a tape over blocks of ore and testing their value by sampling; all this is, we repeat, fundamental, and Mr. Curle has done well in emphasizing this basic fact; but, beyond such necessary procedure, it remains a fact that the attractiveness of mining, that feature of it which requires the most judgment, is the weighing of probabilities in future development. It is on the chances of this that men buy and sell mines, taking bigger risks than Mr. Curle is willing to face, but expecting larger returns also. We venture to doubt whether 10 per cent investments on a basis of ore reserves will ever be a leading feature of gold mining activity; rather, it is the 20 to 25 per cent return with the chances of a speculative enhancement which engages the mine operators who are most successful. After all, the best kind of mining is that actuated by the combined skill and spirit exhibited by the Cornish "tributor" or more modern lessee, or "leaser," who sizes up a certain portion of territory in a mine and takes the risk of developing it, not on ore to be seen in plain view, but on the reasonable expectation of finding something good. It is the experienced tributer's sense and not the money-lender's caution which has built up mining in the past and will make it the great industry in the future.

GOLD MINE ACCOUNTS

(October 10, 1903)

The Editor:

SIR—It is, perhaps, not astonishing that so little has been written on this discussion which Mr. Hoover so comprehensively opened on July 11, but, none the less, I own to a disappointment which must be shared by an important contingent of the profession.

The subject is so large that engineers may well hesitate to attack it in the limited area of "Discussion," and yet I, for one, believe that much can be gained by an unlimbering of ideas upon the subject.

Bookkeeping pure and simple is a matter of arithmetical accuracy and has been developed into a science. Accounting is a broader term and depends for its value upon the proper segregation of items. The subdivision of Mine Accounting (I take the liberty of dropping Mr. Hoover's word "Gold," which seems to draw a distinction scarcely necessary in this country at least) is one of the tools of the mining engineer and one that nowadays is of increased importance; and it certainly seems that the developments in other lines, in Mine Surveying, for instance, or Economic Geology or Metallurgy, have outrun those in this no less important one. It would seem, then, that a discussion of the subject could not but result in a clearer appreciation of the needs of the case and at least a nearer approach to uniformity in practice, though it is scarcely probable that anything approaching the uniformity of surveying methods could be hoped for.

Mr. Jenkins has indicated how easily segregation can be accomplished, and I for one can bear witness to that from personal practice. Probably the majority of engineers would cordially adhere to a practicable uniform system for this. Still, it is

doubtful if any two managers desire, or many mines demand, the same degree or kinds of segregations of costs, so that any "universal" system must be one of great elasticity. We can scarcely expect that mine managers will favor any system that demands the carrying of accounts for which they see no use, so that our proposed system must be capable of simplification to a few basal accounts as well as of infinite elaboration. There are cases where, to properly manage and check up a business and to carry on the "interminable campaign for economy and improvement," the manager may have to subdivide extensively, and it is almost conceivable that there are other cases where the "morbid" misapplication of General Ledger Accounts, spoken of by Mr. Comstock, quite fills the need; and this diversity of need must be duly considered in devising any general system.

But there is a particular class of accounts that have always been a stumbling block, in the handling of which there are serious and fundamental divergences. Mr. Hoover has referred to these in the second column of his discussion, and on another page of the same number of the JOURNAL are two and one-half columns on a similar subject.[1] The gamut of common variations is clearly and concisely run up by Mr. Hoover, while Mr. G. A. Denny, in the "Deep Level Mines of the Rand," expands the matter most luminously. I am referring, of course, to that list of accounts that includes Capital, Depreciation, Maintenance, Reserve Fund, Amortization of Capital and Mine Development Redemption, to use Mr. Denny's own headings in the latter half of Chapter X of his book.

I am not so foolhardy as to open a discussion on these vexed questions here, but the arguments stated by Mr. Denny *pro* and *con* show most clearly the disparate views that may logically be held. In view of this, then, it would seem that the most that could be done in regard to this system of accounts by any such joint commission, as was proposed by Mr. Hoover and seconded with elaborations by Mr. Comstock, would be to urge the general adoption of certain broad principles involving the demand for an explicit statement in each instance as to just what each account included. In regard to the Operating Accounts, segregations should be so made in the books of first entry, even though not carried into the

[1] "Payment of Extension of Mining Plant Out of Revenue." By J. H. Curle. This JOURNAL, p. 48, July 11, 1903.

ledgers, that expert examination could re-apportion costs at any time.

On lines such as these it seems to me that a reasonable uniformity could be expected. Beyond that it would scarcely be possible to go.

R. GILMAN BROWN.

San Francisco, Sept 16, 1903.

CARD SYSTEMS FOR MINE ACCOUNTS

(October 17, 1903)

The Editor

SIR—The use of card systems in multitudinous variation in almost every line of business except mining has now become a recognized essential to proper accounting. We have books of great value explaining in detail the application of such systems to factory costs and to classification and summarizing of expenditures in mercantile houses; the keeping of records in accessible form for practical business purposes is used by banks, trust companies, insurance companies, libraries, physicians, dentists, mercantile agencies, real estate agents, telephone and telegraph companies, gas companies, attorneys, collection agencies, manufacturers, railroads, churches, architects, hotels, publishers, societies and by almost every conceivable class of industries, except those connected with mining and metallurgic practice.

There are some important mining companies, smelting works and mining engineers that have taken advantage of the ready supply of filing cases and card stock in the market to make more or less desultory attempts to improve upon the common slipshod and ineffectual modes of accounting which prevail in these departments. That this practice has not become general is attested by the experience of the writer in consultation on the subject of mine accounts, and very recently by the reading of a paper by Mr. F. W. Denton, which was published in this JOURNAL, September 26, 1903, p. 471.[1]

Without desiring in any manner to detract from Mr. Denton's paper, I merely wish to refer to it as proof that the mining fraternity is far and away behind the times in failing to adopt modern approved methods in the counting house and about the works generally. For there is nothing different in the forms and uses outlined in that paper from what are ordinarily in operation at

[1] "A Card System for Mine Supply Accounts." By F. W Denton. Paper read before the Lake Superior Mining Institute, August, 1903.

thousands of well-regulated commercial establishments not engaged in mining. That the method is new to mining men may be inferred from the fact that the present writer has never run across it in such cases, except where he has himself instituted it, always with gratifying results.

There are features of Mr. Denton's paper which further illustrate what I have found to be the most stubborn prejudice to overcome in installing such systems at the mines. This is the inability to understand how a method which records the minutest details can be made really to save labor and time in actual use. Our author is evidently not aware that the plan adopted at the Baltic mine for supply accounts is but the simple beginning of reform, nor does he appear to realize that his method of writing up the records is but a slight improvement upon the wasteful methods of the majority under the ordinary system.

After a number of years of successful employment of the classified card principle, not only with supply accounts, but with pay-rolls, assays, surveys, the details of mine work, mill work and all other branches of the business, I do not hesitate to say that it provides fully for every detail in such manner as to effect remarkable economy in time, cost and labor, at the same time insuring accuracy, proper checks upon individuals, and, above all, the placing of the accounts in a form to be serviceable as truthful exponents of profit and loss, readily understandable by manager and directors without the aid of expert accountants as interpreters.

The plan given by Mr. Denton does not appear to economize time materially over the ordinary method, although he deems it necessary to emphasize the point that it is no less prompt in operation. Here again I have found great difficulty at the start in convincing old accountants of a thoroughly proved fact, that the records can be so entered as to save time abundantly, and so as to do away entirely with the later work of "writing up." My strict injunction with all card systems, in practice, is *do it now*. This gives the day's own record a completed character, which has untold value in ways only to be appreciated from actual experience. Every night the supervising officer on the ground thus possesses means of checking expenditure at any point or at all points. It is a wonderful incentive to high ideals, a certain as-

surance of prompt detection of error and inefficient service, and it breeds habits of economy and devotion to company interests.

In the Baltic case, Mr. Denton uses the card in connection with memorandum books. They thus become a mere adjunct to the old method instead of a short-cut method in themselves. My plan is very different. In general outline, this is the *motif.* Each and every officer of record, be he foreman, timekeeper, supply clerk or other agent, whether receiver, distributor, consumer or producer, is supplied with cards adapted to his work, and each records his own data without knowledge in common. Some provision is made to check the report of one by that of another. Daily reports are filed at the office, from every department, *on forms especially prepared to epitomize or classify the day's business.* In the office a set of forms is provided to take up summaries of each day's report, on sheets with columns for each summary account, and horizontal numbered lines from 1 to 31. The simple adding of the columns gives totals for each account for the month, or for any minor period, if desired at any time. Columns are provided for values by day and by month, and *everything* relating to the business for the month is in the hands of the accountant on the last day of the month. The manager has available each night a correct replica of the day's business, and can readily strike leaks and lapses at once. Moreover, the whole of the month's business is registered in convenient form for immediate transmission to the home office. This is not a theoretical statement, but one verified thoroughly in my own practice to the full satisfaction of all, from directors and shareholders down to the humblest employee at the mines.

One point must be made perfectly clear, and that is all that space will now allow. The one secret of success in this line is to substitute forms for clerks. The old system of accounting employs cumbersome books of record arranged only by the dates or page numbers, requiring an index or a system of back references. The modern plan here advocated classifies all items immediately, making well-devised forms and self-indexing appliances replace clerk hire, in large measure. By this method, properly handled, I have been able to get large pay-rolls ready with all details of work done, deductions for rent, hospital, store account, etc., within one day of the close of the month, besides having at the accountant's elbow a sufficient daily record of every

detail of each man's employment, indebtedness and balance due him beyond chance of dispute. It is surprising how simple and accurate the method is, once the proper forms have been worked out Here is where the greater part of the brain work must be applied. Common sense and the faithful recording of details *on the spot*, with a filing of forms each evening, will accomplish all the rest, provided that the forms themselves be prepared by a master hand. Perhaps some further illustration may be forthcoming later, if your readers evince sufficient interest to make it profitable.

THEO. B. COMSTOCK.

Los Angeles, Cal, Oct. 3, 1903.

APPRAISING FUTURES

(Editorial, November 7, 1903)

On another page we publish a letter from an experienced shareholder concerning the appraisal of the potentialities of a mining property. Except in the rare case of a mine which has been bottomed, or one the ore reserves of which are restricted within an area already fully tested, there is a "something more" than the ore reserves which has to be included in any valuation. How much value to attach to the varying chances of further successful development is a problem which always comes up as soon as the measurable ore reserves have been determined. From the very nature of the case, no rule can be laid down. How much usefulness and beneficent work would you estimate to be included in the future of a capable man of 40, 50, 60 or 70 years of age? While the amount may be inferred from his performance in the past, neverthless the accomplishment already to his credit may have been won at the expense of his vital powers, and the measure of it might be merely a subtraction from the total to be credited to his whole career. Obviously this reasoning will depend upon whether the man is 40 or 70 years old. At any rate, the simile is not without its counterpart in the case of appraising the future of a developed mine.

A well-known Tasmanian mine has just been made the basis of a company formed in London. The property is capitalized at £500,000; the report of reputable engineers states that it "should be capable of producing a profit of from £95,000 to £100,000 per annum, assuming that the reef maintains its size and value." Should certain extensions of levels and cross-cuts meet with the success anticipated, the ore reserves will amount to a tonnage equal to three years' production on the scale outlined. The mine is worked out down to 718 ft., it has an orebody about 1,500 ft. long, which has been cut, but not proved, at 1,000 ft. Of ore blocked out, there is only 8,500 tons, equiva-

lent to a net profit of about £9,000, and the estimates of future production are based on the expectation of uninterrupted persistence and continuity. Even these estimates show a return of only 60 per cent on the capital, so that a shareholder is taking a fair risk for 60 per cent of his money, and a long shot for the balance. And this is without regard to interest on the investment. In this particular instance, the probabilities of future successful development must be weighed against extremely heavy pumping costs, the full extent of which is a matter of uncertainty, though the government geologist, Mr. W. H. Twelvetrees, who doubtless expresses local opinion, has arrived at the conclusion that the pumping plant, to be installed according to the plans of the company, will prove inadequate. At all events, here is a factor of importance which must offset even the apparent persistence of the ore-shoot upon which the estimates of profits are based.

As the flotation is an honest one throughout, and the undertaking is in the hands of thoroughly capable men, it affords a good example of the ideas of different people upon this difficult question of mine valuation. We would hazard the opinion that, as a rule, with everything looking favorable, a mine in the vigor of its life is worth about half as much again as the net profit in sight, but this refers only to mines which have apex rights and can go down indefinitely on the dip of the lode or have ample territory for further explorations; moreover, it is but a rough approximation of the chances, just as one might say that a healthy man of 40 can reasonably be expected to engage actively in his profession or business for twenty years longer. In practice, the engineer will weigh the evidence in each case—and it will never be the same in any two mines—and he will realize that a property is expected to return not the capital alone, but a high rate of interest during the time required to get the return of that capital. This refers to large developed mines necessitating heavy capitalization; the question of the price of unproved prospects, or likely looking young mines, allows a scope for appraisement beyond the restriction of any general rule. Then comes that insistent and final factor in all these ratiocinations, namely, the personal equation. But that is another story.

APPRAISING THE VALUE OF A MINE

(November 7, 1903)

The Editor

SIR—Your editorial in the issue of October 3, dealing with Mr. Curle's system of valuing a mine, opens the way for a discussion on a point which is often raised in London. Among mining engineers and others familiar with mining operations there is a desire that some system should be adopted for appraising the speculative value of a mine, in addition to the value of the ore blocked out or exposed. When a property is offered for sale, the vendors naturally stipulate that something more than the ore reserves shall be considered when the price is being arranged. This extra value of the mine is at present appraised in a haphazard way, and it usually amounts to just as much as the vendors think they can squeeze out of the purchasers or the public.

It is quite impossible to lay down any hard and fast mathematical formula to meet the requirements of the case, because the chances of the continuity of veins vary with practically every individual mine, or at any rate with each particular geological district. Also, the speculative value varies relatively to the value of the ore reserves, according to the amount of development done. In the two extreme cases of a prospect and a limited proved deposit, the relative values differ widely, for in a prospect the speculative value is everything, while in a property, like some of the Johannesburg mines, the speculative value is at a minimum. In spite of these two very obvious obstacles, I think some general agreement might be found among mining men for dealing with this factor in the value of a mine. Some standard system for reporting might be adopted, so that the opinion of the engineer as to the money value of the chances of further ore being discovered with development might be given without being misunderstood. I am aware that many engineers will object to a proposition which would saddle them with such a grave responsibility, and I admit that, in the hands of men of no professional

pride, this function or duty would be wasted and perhaps misused. The mining profession is so strong in influence for good nowadays, however, that the responsibility might be safely undertaken. Both THE ENGINEERING AND MINING JOURNAL and the Institution of Mining and Metallurgy have done excellent work in checking the abuse of "ore in sight" by inducing engineers to adopt a more definite plan of reporting on ore already blocked out and developed, and the further step of giving an opinion as to the possibilities of the future, over and above the ore actually discovered, would still further assist in suppressing rotten finance and over-capitalization of companies

I give this suggestion for what it is worth, and hope it will receive the attention of mining men.

SHAREHOLDER.

London, Oct 14, 1903

MINING COSTS AT CRIPPLE CREEK

(November 21, 1903)

The Editor

SIR—The geology and vein structure of Cripple Creek have been described almost *ad nauseam* by many writers, but, so far as I have observed, little has been said to the engineering public about the very vital problem of how to make money out of these much-discussed deposits. The impression seems to prevail among mining men outside of the district that Cripple Creek methods are crude and operating costs high. Now, while glaring examples may be produced, in the district, of almost every fault that could be mentioned in the management of mines, I think that the conditions under which the Cripple Creek mine superintendent labors are not thoroughly understood, and that the methods employed, while they may be behind the times in some respects, are yet fully up to the average in others, and even ahead of the average in regard to certain features of mining practice.

A man brought up in the Lake Superior region, where iron and copper ores are mined from underground at a cost of 75c. to $1 per ton, is apt to smile at mining costs of $10 to $15 per ton, even after making every allowance for differences in the prices of labor and supplies. The conditions, however, are so radically different that any comparison on the basis of tonnage is quite worthless. Before the Lake Superior man can arrive at any understanding of mining costs in Cripple Creek, he must realize the two following facts:

1. All ores shipped from Cripple Creek are concentrates produced by *hand sorting.*

2. The amount of development work necessary to find the ores is probably 50 or 100 times greater than in the Lake Superior mines.

At the larger properties of Cripple Creek the cost of mining the total product of ore and waste is only from $2.50 to $3.50 per ton, this cost covering all the outlay of the companies for all

purposes, including taxes, insurance and general expenses. This cost does not compare unfavorably with that of mining in such places as Butte, the Cœur d'Alene, or even Lake Superior, when it is considered that labor at Cripple Creek costs 42 5c. an hour, as against probably 22 5c. in Michigan. It must be remembered that the above cost, of $2 50 to $3.50 for crude rock, includes the cost of sorting the ore, which is equivalent to that of milling in other camps, and is fully as expensive.

It may be said, therefore, that on the basis of crude rock hoisted the Cripple Creek mines have no reason to be ashamed of their costs, as compared with those of other places. This is emphatically the case, in view of the fact that the specific gravity of the Cripple Creek rock is much less than that of lead, copper or iron ore; that most of the rock is broken from shafts, drifts, raises, or from stopes cut out as narrow as possible; that these working places, from their very nature, preclude the use of appliances designed to handle material on a large scale, and that the surface plants are hampered by the fact that, when the mines were started, no attention was paid to any future necessities, and consequently the equipment has been built up piecemeal, and is very far from being economical.

I hasten to state, however, that a low cost per ton, either of crude rock hoisted or of sorted ore shipped, does not necessarily indicate either good mining or good management, and is nearly as apt to indicate the contrary. Two mines may be working in exactly the same kind of ore; and one may ship ore at more than twice the cost for mining that the other does, and yet be doing better work and making larger profits.

To clear up this paradox, it is necessary to call attention hastily both to the character of the ore-bodies, and to the conditions of sale and treatment.

Cripple Creek has always been described as a high-grade camp. This is partly true. The ore occurs in a multitude of small veins, either single or in aggregates. In the small seams which constitute either the vein itself, or a component part of it, the ore is rich, but the rock on the walls, or between the seams, is either wholly or partly waste. The rich seams may vary in thickness from a mere crack to a foot or two, and for these widths may carry from one to several hundred ounces per ton.

There are no large ore-bodies in Cripple Creek. It is doubt-

TABLE SHOWING THE COST OF MINING IN DETAIL

	18,910 tons Stoping, per ton	896 ft Drifts, per ft	1,229 ft Cross-cuts, per ft	112 ft Raises and winzes, per ft
Machine men and helpers and hand miners .	$0 34	$1.86	$2 01	$3 16
Trammers, shovelers, pipe and track men, etc	0 41	1 03	1 04	0 98
Timbermen . .	0 23			1 19
Total underground labor	$0 98	$2 89	$3.05	$5.33
Cost of machines, compressed air, drill sharpening, repairs, etc	0 15	0 97	1 05	1.66
General tramming cost, repairs on cars, oil, supplies, etc .	0 03	0 07	0 09	0 06
Explosives	0 13	1 43	1 66	1 42
Lumber and timber	0 28			1 52
Hoisting and tramming on surface	0 23	0 46	0 53	0 40
General expense, bosses, assaying, surveying, office, etc	0.23	0 58	0 67	0 45
Supplies, miscellaneous	0.04			
Total cost	$2 07	$6 40	$7 05	$10 84

ful if any single ore-body, or even any single vein, has produced 100,000 tons of shipping ore. The largest and best veins have been found in the granite, where the rock-walls themselves are sometimes uniformly impregnated with rock value for a width of 30 or 40 ft. In such places large amounts of clean ore have been mined and shipped without sorting, but only in the swells; when the vein narrows down, it is always necessary to break some waste, in order to make room to work.

The ore, therefore, is mined from veins of such a character that it is impossible to get it out without mixing some worthless rock with it. The problem of handling this ore economically depends on the cost of treatment. This cost is at present—and is likely to be always—so high that it becomes very essential to throw out as much waste, or low-grade ore, as possible before shipping. Could the ore be treated for a dollar or two a ton, the proposition would be entirely different. The rich seams in the veins are always so friable that a large part of the value goes into fine, and can be saved by catching the latter on a grizzly, generally with about ¾-in. space between the bars. Sometimes the proportion of value that can be saved by this method will be as high as 90 per cent, or even more, of the total gold in the

vein. Sometimes it may be only 25 per cent It has also been proved possible to save considerable ore, simply by washing the dust off the waste rejected from the ore-house, and collecting this dust in the form of slime.

It will be evident to anyone who considers these facts that the problem of mining Cripple Creek ore is not so much one of breaking tons, but of saving value. It must be obvious, for instance, that in a vein where the value goes into the fine, it may be very easy to break too much into fines. It may be far preferable to take less out of a stope at a greater cost. It is equally obvious that, after the ore is brought to the surface, it will pay to reject by sorting, even at considerable expense, all rock remaining in the ore that will not pay for freight and treatment. In other words, the problem is not simple, but complex; it is a question of maxima and minima, in which the maximum required is the largest amount of net profit from a given amount of gold in the deposit, while the variables are the cost of freight and treatment, of mining, of sorting, and the value of the rejected waste.

Let us take as a practical example a body of 10,000 tons of ore, running 1 oz. gold per ton. This ore can be mixed and shipped without sorting at a handsome profit, as follows:

Gross value of ore.	$200,000
Cost of mining 10,000 tons, at $3 per ton	30,000
Freight and treatment, $8 25	82,500
Total cost	$112,500
Profit	$87,500

But suppose we reject half of this ore by sorting? By so doing we throw away 5,000 tons that will average $2.50 per ton, or $12,500. The cost of sorting, at 50c. per ton, will be $2,500 more. Then our shipment will be as follows:

5,000 tons, at $37.50 per ton	$187,500
Cost of mining and sorting, $6 50 per ton	32,500
Freight and treatment, $11.25	56,250
Total cost	$88,750
Profit	$98,750

In other words, the gross receipts in this case have fallen $12,500. The cost for mining per ton is more than twice as great; the cost for freight and treatment per ton is $3 greater; the apparent showing by the superintendent very bad; but nevertheless he has made for the company $11,250 clear profit on the transaction

In the first case our total cost for mining, freight and treatment is only $11 25 per ton; in the second case it is $17.75 per ton, but there is more money in the higher cost. This is an example that has been worked out in practice.

It should be very plain, then, that nothing could be more absurd than to judge the merits of a superintendent in Cripple Creek merely by the shipping cost per ton of his ore. Any opinion must be formed on a good many other considerations.

Here, by the way, I wish to avoid giving the impression—which would be a satisfaction to many—that it is not worth while to keep a close record of the costs of mining. On the contrary, this is one point that is too often overlooked. Costs can be kept in the fullest detail at a merely nominal expense. A good system of cost-keeping is so absolutely essential that no property of any size can be run successfully without it. No matter how able a man may be, he can get better results if he knows just what it costs him to do his work. But the costs, once obtained, must be used with discretion, always bearing in mind that the desired result is the greatest *net profit* in dollars and cents, and nothing else.

To give a better idea of the complexity and cost of operating the larger mines of the camp, the following statement of operations at one of the largest properties during one month may be of interest: 18,910 tons of rock were mined from 40 different and separate stopes at a cost of $2.07 per ton, or $39,068.39. The following development work was done in addition to the stoping: 2,237 ft. of drifts, cross-cuts, winzes, and raises in 46 different headings, at an average of $6.91, $15,455.21; ore-sorting and loading cost, $8,999.98. This made a total of $63,523.58. The total amount of rock hoisted, both from stopes and development work, was 24,931 tons, at $2.55, which was reduced by sorting to 7,093 tons of shipping ore, at $8.96.

I think it not unfair to say that these costs are good, considering the conditions. The rock is not excessively hard, but

it cannot be called soft. Part of the rock is ordinary, unaltered granite, and part is equally hard porphyry. Wages will average $3 40 for eight hours. Coal costs about $4.60 per ton, and timber averages $20 per 1,000 ft.

J. R. Finlay.

Colorado Springs, Col , Nov 9, 1903.

SOME ASPECTS OF MINING FINANCE—I

(Editorial, November 28, 1903)

THERE is a good deal in a name. If you call a company "A Syndicate for Floating Mines" or "An Association of Mining Underwriters" you will do for it what was done to the proverbial dog or the infant who succumbed to a shower of ill-assorted names—drowned, as it were, at the very christening. So relief is obtained by a euphemism; the term "exploration company" is comprehensive and includes all sorts of concerns, from those that start out to develop the waste places of the earth to those whose purpose obviously is to test the resources of a credulous public. They have become an institution and play an important part in the development of the mining industry.

Exploration companies are intended in the first place, one may well presume, to explore potential mining regions; but their activity cannot operate in this direction for long, because no organization can continue to pay out money indefinitely; either the cash, which is the first requisite, gives out before any valuable discovery is made, or such a discovery, perhaps several of them, is made, and then it becomes necessary to subdivide the interests into subsidiary companies. Broadly speaking, therefore, the exploration company becomes a financial house, which itself, or with others, underwrites mining issues and directs their policy afterward. The London firm of John Taylor & Sons has been quoted in New York in this connection, but this is an error, for that house is a private concern which undertakes the management of mines on the basis of a percentage of the profits.

For instance, in the case of a well-known Tasmanian gold mine—named the Tasmania—which has just been brought out in London under the auspices of this firm, it appears from the prospectus that the nominal capital is placed at 500,000 shares of £1 each, of which 210,000 are offered to the public at par; the price paid to the local company owning the mine is £20,000 in cash,

and £210,000 in fully paid shares. Intermediate agencies and underwriting commissions bring the purchase consideration up to £320,000 in cash and shares, that is, £90,000 more than the amount actually passed over to the owners of the mine; the remaining £180,000 represents working capital, subscribed in cash to an issue of 210,000 shares offered on the flotation of the company, the difference of £30,000 being cash used in making some of the payments specified

The contracts are in the name of a vendor syndicate, which pays the expenses incidental to the examination of the mine and the formation of the company; this syndicate gets 247,000 shares and £19,500 in cash, out of which it pays for the mine, giving one agent 5,000 shares and another intermediary, mentioned by name, another block of 5,000 shares. The vendor syndicate is practically identical with a Colonial Mines Syndicate which undertakes to subscribe or procure subscriptions for the 210,000 shares, offered for subscription by the prospectus, in consideration of getting £53,500, payable as to £10,500 in cash and £43,000 in shares. There are sub-underwriting agreements between the Colonial Mines Syndicate and various other parties at a commission of 25 per cent, payable as to one-fifth in cash and the balance in fully paid shares. Thus it comes to this, that the vendor syndicate receives 37,000 shares, out of which two of its agents get 10,000, and a commission of about 25 per cent for its services in giving a guarantee to place 210,000 shares. The directors are holders of stock in the syndicate and participate largely in the profits of the flotation, while also subscribing (under sub-underwriting arrangements) for the shares now offered. All the contracts are given in the prospectus in a manner which exemplifies the beneficent operation of the Companies Acts. Finally, it is stated that John Taylor & Sons, who individually are members of the syndicate, and two of whom are also directors, have agreed to serve the company as managers and consulting engineers in consideration of receiving £850 per annum in salary, office rent, etc., "and in addition 2½ per cent of the net profits distributed by the company in every year, whether in the shape of cash or shares, but such additional remuneration shall not exceed in any one year the sum of £2,500." It appears to us that the terms and conditions are fair enough and that the professional services of the engineers are secured on a decidedly reasonable

basis Concerning the value of the mine, we can express no opinion.

John Taylor & Sons has existed for three generations; the firm began by undertaking the direction of mines, and eventually also, in certain cases, as we have seen, it has assumed part of the responsibility of finding the capital necessary for their development; thus the financial side grew out of the professional. With the Exploration Company, Ltd., the purchase of profitable mines led to the technical management of them *after* their acquisition. Both companies, the one distinguished by the possession of a lot of old-fashioned, but sound, mining experience, the other assisted by the capital of a great Jewish family, have been distinctly successful. The Exploration Company is a limited-liability company which makes a business of promoting mining properties. Ever since Hamilton Smith induced the Rothschilds to take part in the organization of this company and it was followed by the Mining and Financial Trust, the Mines Development Company and other similar undertakings, there has been a steady growth in exploration companies of every kind. We refer, of course, to those interested in American mines, for South African finance covers a field quite apart.

In London the formation of land and finance corporations has proceeded without limit, a large part of the indigestible financial paper now fluttering in that city being of this description; but it is only of late that the same manifestation of mining activity has become apparent in New York. There are so many "American" and "United States" and "Mexican" Finance, Exploration, Development, Securities, Investment and Prospecting companies that it is extremely difficult to prevent confusion, through mere similarity of name, between the few substantial concerns and the larger number of ephemeral creations. This activity in the financial incubator is due largely to the success of the English companies, but more particularly to the conspicuous position acquired by the Guggenheim Exploration Company, one of the many channels through which flows the irrepressible financial energy of a large family of extremely clever men. Their success has prompted others to organize for the same purposes. Mining engineers who have grown gray in active service have viewed with chagrin the wealth acquired by one or two of their own profession whom financial participation has made rich in a few years,

and have come to the conclusion that they, too, would take their part in the more lucrative branches of that many-sided, diversified and elastic occupation which is covered by the comprehensive term of "the mining business"

Hence the partnership between engineers and bankers, engineers and promoters, engineers and adventurers, engineers and irresponsible schemers, until the financial arena has become as much of a medley as the stage of an opera at the moment of the grand climax. A man at forty is either his own doctor or a fool; an engineer who has surveyed mankind from China to Peru needs no advice; yet, could we but presume on friendship, we would say to him that the promotion of companies is entirely outside his professional training and is best left to those that are bred to the business. Many a good engineer has been lost in the unsuccessful promoter; one man, with more of the financial instinct than the professional, wins; but for every such case a hundred wreck their careers in their eagerness to drive cross-cuts to wealth.

It is a difficult problem; the engineer is entitled to his share of the profits of mining, and he should receive a reward no less than that of the promoter. Should he therefore become a partner with the capitalist? The same question has often arisen as between the architect and the contractor; an architect can join with the contractor in the risks of the building trade; he may himself become a contractor and, not content with making drawings only, proceed to build the structures which he designs. Nevertheless, the division of the work and the separation between the two occupations is to the gain of the individual, no less than of the community. It is again a question whether the shoemaker should stick to his last or take up a task which belongs, by fitness and by custom, to the tailor.

SOME ASPECTS OF MINING FINANCE—II

(Editorial, December 5, 1903)

WE have seen more than one prospectus, issued of late by exploration companies organized in New York, in the pages of which reference has been made to the successes of similar undertakings in London and elsewhere. Several English organizations are quoted by name as examples of this kind of business activity, but it indicates how little is known concerning the ins and outs of the London arena, when three or four corporations, of entirely dissimilar character and methods, are given as models for American enterprise. On the other hand, the mere fact that London has been the leading mining market of the world since the modern development of mining began, warrants our turning thither for examples of well considered methods in the management of financial organizations. By the mining men of this country, the Exploration Company has long been held as the typical London house making a business of promoting mining undertakings. In many respects there is a warrant for this, although it must not be assumed that even this highly reputable concern has been uniformly successful. A few years ago it illustrated the dangers of ill-considered and reckless finance, by taking up mines in Australia, for instance, without much regard for business caution; and finally embarked in tramway enterprises in Paris which entailed a loss of fully $3,500,000. The Exploration Company has paid for its experience, and in returning, of late, to conservative mining, it has recovered much of the ground lost during a period of poor administration. Experience teaches, and whatever methods this company may now employ are those therefore which, after trial, appear most likely to eliminate the risks of mining as much as possible, while at the same time giving that *quid pro quo* which is the essence of sound business.

Some of the recent methods adopted in connection with well-

known mines will prove suggestive to those who may set out on the same quest.

When the Exploration Company acquired El Oro mine they took an option to purchase, from Mr. Haggin and his partners, the whole of the shares of the American Mining Company, which owned El Oro mine, and then formed the English company with a capital of £900,000; this represented the cash purchase consideration for the property, plus working capital, and left some few thousand shares unissued, in the hands of what is now El Oro Mining & Railway Company. In other words, the Exploration Company turned over the property complete to the English organization at absolute cost and without adding a dollar by way of profit, and, in addition to all this, itself defrayed the cost of registration and all the expenses incidental to the formation of the new company. The Exploration Company then solicited subscriptions from its friends in London toward the capital of El Oro Mining & Railway Company, charging them 5 per cent, or one shilling per share, which represented the Exploration Company's profit; but inasmuch as the vendors took a large number of shares in lieu of cash, and could not, therefore, be asked to pay this one shilling per share, and as, of course, the amount subscribed by the Exploration Company itself did not represent any profit (as it also had to pay commissions, expenses, flotation charges, and so forth, out of the profit it did receive in this manner), the net gain of this large transaction did not exceed £15,000. It is perhaps the only instance in which an English company has acquired a property at absolute bedrock cost; and, barring that satisfactory result of the transaction, it cannot be said that this method of treating a property is a good precedent or a reasonable business proposition.

In the case of the Tomboy mine, the Exploration Company followed what is known in London as the Hamilton Smith practice; that is to say, they purchased 51 per cent of the shares of the American company, and merely subscribed, and induced their friends to subscribe, for the shares in that company. Subsequently, finding this scheme did not work at all, they persuaded the American directors to sell out the whole business to a company formed in London, and the American stockholders now hold shares in the English company, instead of the English stockholders holding shares in the American. This is also a

practice which does not at all commend itself, for, while 51 per cent, of course, gives the control of a property, it is obvious that the sale of a few thousand shares will transfer that control

The practice now adopted by the Exploration Company is approximately as follows If a mining property is brought to the notice of any one of its representatives, and he (an engineer) is satisfied with the preliminary investigation, they arrange to take an option upon the property, preferably for about three months; and if it then holds up to a complete and searching examination, they, prior to the expiration of the option, form a company in London to acquire the mine, making themselves responsible for the purchase, offering to their friends a participation in the underwriting, for which probably a commission of 5 per cent in cash is paid; then they make a public issue, and if the business is of sufficient dimensions, they reserve a certain number of shares for preferential allotment to the shareholders of the Exploration Company, should they be disposed to make application for the same.

The capital of such a new company is fixed at the cost price of the property, plus whatever may be necessary for working capital; and, in addition, a sum from 5 to 10 per cent, according to the size of the property, is set aside as the promoters' (Exploration Company's) profit; unless a mine, on examination, shows that it can stand such promoters' profit, and still present a good mining chance of giving the shareholders their money back with a substantial rate of interest, it is not considered good enough to put on the market. Of course the amount of commission which the promoters should add to the purchase price would very largely depend upon the size of the property, for what might be a reasonable percentage on a purchase price of $500,000 would be excessive and unreasonable on a property of $5,000,000.

The phrase "underwriting the capital" means that the organization bringing out a company with a capital, say, of £1,000,000, would by themselves and their friends undertake to subscribe for the whole or any portion of the capital not taken by the public, and in consideration for such guarantee they would be paid an underwriter's commission of, say, 5 per cent. The foregoing, of course, only applies to mining properties too big for the promoting organizations to handle alone, but in the case of any

mine which could be purchased and equipped for, say, \$500,000, or even \$1,000,000, if the property was considered to have attractive prospects, the Exploration Company would be much disposed to take the whole for its own account, and work it as a private business.

SOME ASPECTS OF MINING FINANCE—III

(Editorial, December 17, 1903)

WE have described some of the methods adopted by conservative houses engaged in the acquisition of mining property. There are several well-managed financial organizations in London, such as the Consolidated Mines Selection Company, which do not float mines "off their own bat," as it were, because a single undertaking of any magnitude would entail the absorption of most of their capital; therefore, instead of using up their resources in one big deal, they participate in several ventures. Either they obtain an allotment of interest in a business about to be issued by another house, and, having had the mine examined by their own engineer, they accept the participation; or, their agent having secured an option on a likely-looking property, they offer it to a larger concern and obtain a consideration, as well as a participation, for their instrumentality in introducing a profitable deal. Furthermore, many successful companies of this kind do not buy mines at all, but purchase blocks of shares on the open market, after their engineer has investigated conditions at the mines; that is, they maintain a staff of trustworthy engineers and obtain correct information concerning the ore reserves and future prospects of mining properties already listed on the exchange, utilizing this first-hand knowledge to acquire an interest whenever the quoted price warrants a purchase. Should their holding become large, they can usually arrange to obtain representation on the directorate of the mining company.

The Consolidated Mines Selection Company is the result of the amalgamation of the African Metals Company and an older exploration company, organized by Mr. Walter McDermott, named the Mines Selection Company.

The Mining and Financial Trust may also be quoted as having been founded on a sensible basis, and, although it is a concern which has withdrawn into the privacy of inactivity, it played

an important part in the development of many celebrated American mines, among which the De Lamar, in Idaho; the Elkhorn, in Montana, and the Harqua Hala, in Arizona, may be instanced. Mr. T. A. Bennett was the founder of this company. He gave his services as mining engineer on the understanding that he was to receive no salary or retainer, but a large share in any business resulting from his active search for a good mine at a fair price. He stipulated only that his expenses should be paid when he was actually in the field. This was a fair and practical scheme. It worked successfully, until the disappointment of the Harqua Hala gave a severe check to the further expansion of the company.

The Mines Company, Ltd., was another concern which took an important part in American mining. It was formed by Mr. John Darlington and others, and was responsible for bringing out the Yankee Girl, New Guston and American Belle mines at Red Mountain, Colorado, but it lost its standing through the over-capitalization which marked the last of these three important flotations.

Then, there are all sorts of venturesome concerns, which make a brief splash or a long-continued splutter, following risky methods which may be described as financing on the edge of a razor. Every once in a while they get a brief notoriety, commencing in the financial press and ending in the police court. Several exposures of folly and trickery have discredited mining during recent years, but the dreary messes of Bottomley, Hooley and Wright are brushed aside as episodes to be forgotten with the indecency of a hurried funeral. In truth, they represent but the more extreme forms of reckless finance, which are no more a part of legitimate mining than the iniquities of the race-course are necessarily a part of the business of breeding good horses.

SOME ASPECTS OF MINING FINANCE—IV

(Editorial, December 24, 1903)

MANY "development" and "exploration" companies, which start with good intentions, slide down an easy descent into wrongdoing, merely from the lack of funds. Let the organizers of such enterprises realize this brutal fact: you cannot finance legitimately without money. To such gentlemen as are organizing "exploration" companies we would give the advice which the Austrian general, Monticucoli, is said to have given to Maria Theresa, when he told her that three things were necessary for waging war successfully—the first was money, the second was—money, and the third was—money! Unless a financial company has funds sufficient to carry out its undertakings, it will either be squeezed against the hard wall of adversity, or it will stoop to questionable practices. It is as difficult for a promoting concern to be uniformly honorable, when trying to carry out big undertakings with a small capital, as it is for the wicked man to enter heaven. No array of names, or multiplicity of business interests, will suffice. The *malice des choses*, which pursues the poor financial company trying to push large operations, is one of the brutalities of existence.

On the other hand, the utilization of a very large capital, in actual purchase of properties, is not within the scope of the typical exploration company. Such action leads to a crippling of resources, because it requires the further use of funds in the support of the market for its own issues. A company which brings out a big mine, and becomes itself a large purchaser of the stock, is apt to be the butt of successful bear attacks, unless it is in a position to protect its holdings. The story of Lake View Consols, Le Roi, and other mines which have suffered queer vicissitudes on the stock exchange, illustrates how dangerous it is for an issuing house to be "long" on its own shares.

An exploration company, primarily, is not an investment cor-

poration, but a house of issue; its most profitable avenue of energy is in scouting for good mines, in order, by sifting a large number of likely properties, to secure the option finally on one which, after thorough examination, it can commend to its clients. In this business, as in all others, it is a mistake to confuse the operations of a broker with those of a principal. The exploration company will find it advantageous to act mainly as a corporate broker, for the buying and selling of mines. Therefore, a capital sufficient for active scouting, and the thorough investigation which comes after picking out the mines that warrant it, together with necessary payments for options, should suffice. A capital of £100,000, or $500,000, should be ample for all work of this kind, during a period of several years, but it must be available as cash. With such a capital, it is possible to pay a 50 per cent dividend on the completion of a successful deal, while, at the same time, there is money enough to meet the expenses of a prolonged and extensive search for that most desirable business —a profitable mine with possibilities of development.

Having finally found and secured a good mine at a fair price, the next step requires as much judgment as any which have preceded. Companies which try to make a *grand coup* on one transaction, regardless of rhyme or reason, always meet with a most miserable smash sooner or later—usually sooner. In these matters, as in most of the affairs of life, it is both right and good policy to take a large view of business, and build it up by uniformity of fair dealing and cautious finance. A company which can make two or three sound deals, without over-capitalizing a mine or sand-bagging a mine-owner, is assured of a prosperous career, for such a reputation will bring to its office a large share of the best mines that come to market. On the other hand, experience shows that, with rare exceptions, most finance companies which have made one or two successful flotations become so greedy that they proceed to over-capitalize their next issue, and strain to make so large and quick a profit as to end in a miserable fiasco. The American Belle flotation (which was brought out when the Guston and Yankee Girl mines had won a reputation for the Red Mountain district, and to the company which issued them) is a case in point.

But we are treading on dangerous ground, where guides do well in warning the wayfarer while refusing themselves to go for-

ward. In these matters an intelligent cognizance of what has happened to others is much cheaper than the bitter pill of experience, which is the inevitable medicine doled out to the heedless and unwary who tread along the difficult path of mining finance. At a time when new exploration companies of every kind are being organized in New York, it will not be held improper to dwell upon the dangers which they may encounter, the success which they may win, and the stimulus they can afford to legitimate mining.

SOME ASPECTS OF MINING FINANCE—V

(Editorial, December 31, 1903)

ONE form of unpractical finance which is prevalent in this country is unknown in England. We refer to the organization of companies with a large nominal capital, say, 1,000,000 shares, a part of which is given out as fully paid stock in exchange for the mine, while the balance is peddled at a big discount to the public in order to secure working capital, and, in many cases, to make a quick profit for the concern at the back of the operation. Such practices are rendered impossible in England by the Companies Acts, regulations covering the organization and procedure of corporate enterprise. Under the lax statutes obtaining in several States a syndicate can take over a small mine or a mere prospect, organize a $1,000,000 company, pay the owners (themselves, it may be) 550,000 shares, carrying no liability, and sell the minority interest or remainder of the stock at 10 or 15 cents; sometimes even less, especially when a "fiscal agency," as the promoting concern is apt to call itself, represents a number of mines in course of development and "pools" the various shares so as to make a combination or "bargain" offer, in order to procure the money needed to make mines out of holes in the ground. The price of the stock is raised according to the circumstances, and among these circumstances the needs of the mine are apt to be less of a measure than the facility with which the stock can be sold to simple-minded people in a fool's hurry to get rich.

There is an enormous amount of money subscribed, and mostly lost, in this way during the course of a year, especially among servant girls, clerks, railroad conductors, tradesmen and hard-working people with small salaries. Iowa, Illinois, Indiana, and the regions most out of touch with precious metal mining, are fertile fields for enterprising organizers of such schemes. Office-holders of local repute, or other persons of some notoriety, are made directors and are given blocks of stock, to the intent

that they may serve as lures to the people in various localities. Then reports of progress are sent in by self-constituted "experts," and "dividends" are declared, out of the subscriptions, so as to hasten the instalments on the stock; for it is usually sold on this plan, so much per month out of the earnings of comparatively poor individuals. These are the undertakings which are liberally advertised in the daily press and in the illustrated weeklies.

During the recent prosecution of a notorious mining promoter, it was shown that out of 1,250,000 shares, valued at $1 per share, in a company operating a mine in Oregon, there were issued, and held, 25 shares in California, 14 in Canada, 11 in Delaware, 106 in Illinois, 25 in Indiana, 422 in Iowa, 61 in Kansas, 16 in Maine, 27 in Maryland, 63 in Massachusetts, 14 in Mississippi, 49 in Missouri, 48 in Nebraska, 18 in Minnesota, 16 in New Jersey, 68 in New York, 95 in Pennsylvania, 70 in Washington, 50 in Wisconsin, and the remainder in other States of the Union. This distribution suggests forcibly what efforts must have been made to sell the shares wherever a gullible head bobbed up.

The favorite scheme for such undertakings is a "tunnel" or adit which is to pierce a mountain and intercept large numbers of veins. A string of mining claims is easily secured for a merely nominal sum in a half-deserted portion of some well-known mining district, and any present unproductiveness is explained by excess of water, cost of shaft-sinking and other drawbacks, which are to be removed through the facilities afforded by such a drainage adit. Ideal cross-sections exhibiting a multiplicity of veins, an extremely steep contour of the surface, and ore reserves commensurate with tremendous "backs," are added to highly colored descriptions of the future of the undertaking. Shares are offered at 10 cents, to be increased to 25 cents within a specified period, and other advances may ensue, dependent upon the replies evoked by the circulars which are sent out, and the advertisements and favorable reading notices which appear in all kinds of papers, religious and old-fashioned periodicals being preferred by this type of promoter. A rather unique method of advertising a gigantic mining swindle some time ago was the sending of "lecturers" throughout the country on a special railroad car; the duty of these fakirs was to tell the unsuspecting inhabitants of the smaller towns how fortunes had been made by investors in mining shares, and to expatiate upon the millions that lay idle in the

"treasure vaults" of the property, the stock of which was offered at "rock-bottom" prices. As the work at the mine proceeds, the impatience of the ignorant investor is fed with accounts of rich strikes, veins one inch thick crossing a working 5 ft. wide being likely to appear as "ore 5 ft. across," while assays of specimens of walnut size are quoted under the guise of "averages" When, eventually, some of the subscribers cease to send in their instalments, they forfeit their interest, and the anxiety of the survivors is allayed by reports of "well-known experts" and "professors," who are vouched for by State officials or country bank-managers in a magnificently vague manner permitting of easy retreat. Sometimes a withered enterprise will receive a new lease of life by reorganization or consolidation with another property equally worthless, and the unsophisticated shareholder is again called on to contribute by surrendering his old stock and paying an additional fee for the new shares. And so the mockery of mining goes on, until the money subscribed has all been used up in salaries for the insiders, and finally a hole in the ground with a dump is seized by an irate stockholder, whose first touch breaks down the whole house of cards—marked cards, at that. The South Sea bubble and its associated frauds of the year 1720 have many a counterpart, even in this day and generation. What we chiefly object to is, they are described as *mining*.

MINING FINANCE

(December 10, 1903)

The Editor:

SIR—I hope that your articles on "Mining Finance," recently published in the JOURNAL, will be widely read, and will serve to give the public better ideas on that subject, and especially on the proper function of exploration companies. The public, even that portion which concerns itself at all about the subject, has very hazy ideas of mining finance. I have even met mining engineers, who were well up in their profession, but were rather like a sailor on horseback when it came to the financial part. If people who have money to invest would only look into this matter more, there would be fewer complaints about mining investments. How often we have seen fairly good mining propositions hampered by capital out of all proportion to their value; and, on the other hand, we have seen mines kept back in their development for want of money, which could be well spent upon them.

I was specially interested in what you have said about exploration companies and their proper functions. The popular mind has been somewhat confused on this point. Quite a number of people, I find, have a general idea that an exploration company is something like the "holding company"—that pernicious modern device, which has played such a malignant part in railroad and industrial finance, in the last two or three years. We have one conspicuous example of the "holding company" in mining, which many investors know to their sorrow. The less said about it the better; it is certainly not an exploration company.

The greater part of the public knows the exploration company only through the glowing advertisements of the promoters and stock peddlers, whose brilliant imaginations have seized upon the idea of exploration and finance companies as capital devices to aid in fleecing the unsuspecting outsider. The very titles are alluring, and they permit the use of gorgeous prospectuses, unhampered by any regard for truth. If the promoter has one

particular mine to describe, he finds inconvenient limitations, the possibilities of finding an indefinite number give his mendacity full scope. But this is inevitable, since all good things may be perverted to evil ends; and this incidental abuse does not destroy their real usefulness.

It does not seem to me that we have ever had a really satisfactory mining market in this country. I do not mean by this a mining stock market, but a market in which mines, or good properties, can be disposed of in a satisfactory way. The prospector, or the mining engineer, who has a promising mineral property, needing capital for its development, often does not know where to go. If he has no friends with money, it is not an easy matter to secure his capital or dispose of his property. Too often he falls a victim to the promoter or to a broker of the conscienceless class, who reaps all the profits. The exploration company—or companies, for there is room for more than one or two—of the right kind would help very materially in making the market that is wanted. Such companies, too, when well established, would be in a position to command the attention of investors, large and small. Of course, they will be liable to make mistakes sometimes; but, with any sort of good management, the proportion of such failures will not be large.

I hope you will be able to develop further these ideas, which I have expressed in what, I fear, is a rather inconsequent way. I want to see general investment in mines increase, for I know that, if reliable ways of doing it are provided, such investments will be far better for the public than the putting of their money into blind pools and watered industrials.

INVESTOR.

New York, Dec 6, 1903

RESUING IN UNDERGROUND WORK

(December 10, 1903)

The Editor:

SIR—The article appearing in your issue of September 12 (referring to the origin of the term "resue" as applied to underground work) brings to mind some practical experiments carried out by the writer a few years ago, in which an attempt was made to determine the relative merits of this system of dealing with narrow veins of high grade, as against the method of breaking the reef and adjoining rock, together with an idea of sorting out a high percentage of the non-auriferous product. In the cases cited the adjoining rocks, or walls, of the vein contained no gold, the inclination of the vein was 85° from the horizontal, and the section of footwall taken out in the first instance was separated from the vein by a clear plane and was broken without disturbing the ore. The average width of heading or breast in the first operation was 30 in. and the total width of stope after the reef had been extracted was 36 in. In the second operation the maximum average width of stope was 30 inches.

The two methods were, respectively, as follows:

When resuing was applied, the vein was first stripped on the footwall (which, in this case, was the more economical to handle) to a width of 30 in. This waste rock was used largely as filling, although a certain percentage was necessarily sent to the surface. When some 3,600 sq. ft. of quartz had been stripped, this was broken down as a clean product, so that no sorting was required.

In the second case, the quartz and adjoining rock were broken together, and the fineness to which this product was reduced allowed of sorting out only 5 per cent of the barren rock.

The following figures are compiled from these experiments, and although the period over which the work was extended was of necessity limited, and is possibly not an absolute guide as to what the work should cost under similar conditions over large

areas, they indicate the most profitable method of handling ore occurring under these conditions.

Example A shows a loss of $23.76 on the operation, while in B, where resuing is resorted to, a profit of $1,469.40 is made. In both cases 6 in. of quartz was dealt with.

In the second comparison, C and D, a 12-in. vein valued at 30 dwt. was worked, and while the discrepancy is not so marked, it is shown that under these conditions there is still a considerable margin in favor of resuing. The last example, E, is purely theoretical, as far as the percentage sorted is concerned, and is given in further support of the contention held.

Comparisons Between Stripping Narrow Reefs and Stoping them with Waste

Example A.—Width of reef, 6 in ; value, 50 dwt. Stoping width, 30 in ; value, 10 dwt. One ton contains 20 per cent of reef and 80 per cent of waste; 5 per cent is sorted, 5 per cent of 80 per cent is 4, leaving 76 per cent of the waste. So that 96 per cent goes to the mill with a value of 10.41 dwt. per ton. Recovery equals 75 per cent of 10.41 dwt., that is, 7.8 dwt. at $0.96, which is $7.49. One hundred tons at $7.49 is $749 On a basis of 100 tons milled it is necessary to charge

To mining	104 tons at	$3 60	$374 40
" tramming	104 " "	0.36	37 44
" hoisting	104 " "	0 18	18 72
" milling	100 " "	1.44	144.00
" redemption	"	0 72	72.00
" charges, general	"	0 66	66 00
" pumping	"	0.60	60.00
Total expenses for 100 tons			$772 56
Value of gold recovered, 100 tons			748.80
Loss			$23.76

Example B —Stripping, 30 in. of waste and mining 6 in. of clean reef Width of reef, 6 in ; value, 50 dwt. per ton. Recovery, 75 per cent of 50 dwt , that is, 37.5 dwt. at $0 96, or $36 On a basis of 100 tons at $36, $3,600, it is necessary to charge·

To mining 500 tons of waste, at $2 40.	$1,200 00
" milling 100 tons of reef, at $3.60	360 00
" handling 110 tons of waste, at $0.48	52.80
" tramming 100 tons of reef, at $0 36	36 00
" hoisting 100 tons of waste, at $0.18	18 00
" hoisting 100 tons of reef, at $0.18.	18 00
" milling 100 tons of reef, at $1 92.	192 00
" redemption, at $0 96	96.00
" charges, at $0.84	84.00
" pumping, at $0.72	72.00
Total expenses for 100 tons	$2,128 80
Value of gold recovered, 100 tons	3,600 00
Profit by stripping	$1,471.40

Example C.—Width of reef, 12 in., value, 30 dwt. per ton. Stoping reef and waste together. Average value of 30 in., 12 dwt., 40 per cent of this is reef, 60 per cent is waste, 5 per cent is sorted, equal to 3 per cent of the waste; leaving 97 per cent to mill, averaging 12.4 dwt., 75 per cent recovery of 12.4 dwt. is 9.3 dwt. per ton. Value of gold in 100 tons (9.3 dwt. at $8.93) is $893.

	Tons	Cost	Total
Mining	103 at	$3.60	$370.80
Tramming	103 "	0.36	37.08
Hoisting	103 "	0.18	18.54
Milling	100 "	1.44	144.00
Pumping	100 "	0.60	60.00
Redemption	100 "	0.72	72.00
Charges	100 "	0.66	66.00
Total expenses for 100 tons			$768.42
Value of gold recovered			892.80
Profit			$124.38

Example D.—Stripping 12-in. reef. Value, 30 dwt., 75 per cent recovery is 22.5 dwt., or $21.60. Value of gold in 100 tons at $21.60 is $2,160.

	Tons	Cost	Total
Mining waste	250 at	$2.40	$600.00
Mining reef	100 "	3.60	360.00
Handling waste	23 "	0.48	11.04
Handling reef	100 "	0.36	36.00
Hoisting waste	23 "	0.18	4.14
Hoisting reef	100 "	0.18	18.00
Milling	100 "	1.92	192.00
Pumping	"	0.72	72.00
Redemption	"	0.96	96.00
Charges	"	0.72	72.00
Total expenses for 100 tons			$1,461.18
Value of gold recovered			2,160.00
Profit			$698.82

Example E.—Width of reef, 12 in.; value, 30 dwt. per ton. Stoping reef and waste together, 30 in. wide, and then sorting 20 per cent of the rock mined. Value of rock before sorting, 12 dwt.; after sorting, 15 dwt., 75 per cent extraction gives 11.25 dwt. recovery; 100 tons at 11.25 dwt. at $0.96 equals $1,080.

Expenses

Mining 125 tons at $3.60	$450.00
Tramming 125 tons at $0.36	45.00
Hoisting 125 tons at $0.18	22.50
Sorting 25 tons at $0.96	24.00
Milling 100 tons at $1.44	144.00
Pumping 100 tons at $0.60	60.00
Redemption 100 tons at $0.72	72.00
Charges 100 tons at $0.66	66.00
Total expenses for 100 tons	$883.50
Value of gold recovered	1,080.00
Profit	$196.50

These figures reflect the importance of carefully weighing the merits of the two methods of stoping when dealing with narrow veins

F. C. ROBERTS.

Bulawayo, Rhodesia, Oct 27, 1903.

GOLD MINING IN RHODESIA

BY F C. ROBERTS

(December 10, 1903)

Introductory—Lying between latitudes 16° and 23° south, and longitudes 25° and 30° east, Rhodesia, which, a few years ago, was almost wholly inhabited by native tribes, can now boast of a white population of about ten thousand. The country derives its name from the great founder, Cecil John Rhodes. In its physical aspects Rhodesia differs from most of the Western mining States of America, in that few really high mountain ranges traverse the country. The mining districts embrace numerous small hills which gradually fade away into large areas of, first, undulating and then almost flat, plains. In the granite belts an independent type of scenery is presented, consisting of wide, slightly undulating plains, dotted with countless small conical hills (kopjes) varying in height from 50 to 300 feet.

In but one instance in the whole of Rhodesia has it been found advantageous to attack the ore-bodies and veins through adits; practically every mine in the country has been opened up through shafts. The gold mining industry at the present time is the only industrial source of revenue, and presents certain aspects difficult to compare with those existing in other countries. The vicissitudes to which Rhodesia has been subjected have been numerous, unique and costly; they have militated against the energy and enterprise which have been thrown into the country, the progress of which has been sadly retarded in consequence.

The internal system of railways, which is now being extended over the country, will bring within easy access of the centers, Bulawayo in Matabeleland and Salisbury in Mashonaland, every mining district of importance, and thereby remove the hindrance due to prohibitive prices and scarcity of wagon transport. An independent line, 200 miles long, which is practically the first lap in the Cape to Cairo railway, from Bulawayo via Victoria Falls, will

tap the Wankie coal-field by the end of November. The Wankie coal will then be available for use in practically every mining district of Rhodesia.

Geology.—Geologically, those parts of Rhodesia which have been at all explored present much the same features as other quartz countries. In two instances, however, we are favored with geological problems which promise to be of especial interest and importance, and in both instances the commercial aspect of the inquiry will stimulate scientific investigation. I refer to an auriferous diorite in the one case, and an auriferous hornblende porphyrite in the other.

No geological survey has yet been made in Rhodesia, hence only a generalized description is possible. By far the greater portion of the country consists of granite rocks, in wide belts, having a strike somewhat west of north and east of south. The gold belts embrace the areas characterized by slates and schists, varying in extent from a few hundred yards wide by half a dozen miles in length, to 15 miles wide by 30 miles in length. These metamorphic rocks are traversed by numerous dikes, consisting of the many varieties of diorite. In the valleys, or small gulches, of the hill country, the alluvium is of very limited extent, suggesting a lack of those extreme climatic conditions necessary to produce rapid erosion.

The quartz veins include several distinct types; the most common are the interlaminated veins, which are found abundantly in the foliated rocks, though numerous segregated veins also exist. The quartz occurs generally in lenticular bodies, sometimes distinctly isolated, but more usually in parallel series, exhibiting great variations in width and vertical persistence. On the whole, the veins are narrow and their lateral extent is rather limited.

At the Ayrshire mine in Mashonaland an auriferous diorite is under exploitation, but as yet little is known of the genesis of this most interesting occurrence. A large amount of work has been accomplished laterally, and the vertical depth reached is over 600 ft. The irregularity of the gold contents of the dike and various other characteristics would seem to support the lateral secretion theory.[1]

[1] The gold-bearing diorite of the Ayrshire mine was discussed in this JOURNAL, under date of July 11, 1903, p. 44, by Mr. E D. Berrington, and, on October 3, 1903, by Mr. J. E. Spurr

The writer has lately discovered an auriferous hornblende porphyrite. This rock is most interesting petrographically, and is quite uncommon in this country. It consists, as seen under the microscope, "of large crystals of feldspar (chiefly plagioclase), possibly with some orthoclase and smaller calcareous pseudomorphs after hornblende, retaining good crystal outline, imbedded in a fine-grained feldspathic ground-mass. The feldspars are somewhat crushed and the alteration of the hornblende implies a certain amount of water action." This body has recently undergone exploitation, and appears to predominate in the moulding of a small range of hills rising 500 ft. above the surrounding country. In close proximity to the porphyrite are the crystalline schists. A superficial examination shows considerable variation in width, the maximum being about 150 ft., while the lateral extent will probably reach 1,000 ft. or more. Enough work has not been done to decipher the geological structure, nor can an intelligent idea, as yet, be formed with regard to the origin of the gold content. Samples taken over the various widths exposed give from 2 to 15 dwt. per ton, and although these results are not representative, they indicate an occurrence of unique character.

Ancient Workings.—An interesting feature of Rhodesia is the fact that every auriferous district has been largely worked by an extinct race, popularly referred to as the "ancients," and although some relics left by these people have been found in the bottom of old stopes lately opened, as well as among the numerous ruins existing in the country, no satisfactory explanation has been advanced touching their identity. The amount of work accomplished and the quantity of gold, copper and iron extracted by them must have been enormous. While the remains of these workings have largely aided the prospector during the modern reopening of the country, when conditions were more or less abnormal, there is little doubt that their effect has tended to hinder the introduction of a thorough system of prospecting, and has in a great measure deflected attention from the large areas containing virgin reefs. Several calculations of the amount of gold extracted by these "ancients" have been made; these estimates are hypothetic and no accuracy is claimed for them, but the latest reach $300,000,000. It has been the custom to judge the value of a mining proposition in Rhodesia by the extent of

the "old workings," without regard to geological considerations, hence many disappointments.

The knowledge displayed by the "ancients" in determining the value of the ore was indeed marvelous It is not to be assumed that they realized width of vein as an important factor, but it would appear to have been a sufficient encouragement to them that a vein contained, say, a minimum value of 10 dwt. per ton. This work no doubt extended over a very long period, for wherever the rock was not readily softened by weathering, they built fires against the stope-breasts and then threw water upon the heated rock so as to induce fracture In some instances, where it is evident from the contours that water was not encountered, they worked to a depth of no less than 250 ft on the dip.

Financial Considerations.—The British South Africa Company formerly had the right to demand up to 50 per cent of the vendor's interests, but this right was seldom exercised to its full extent; it has now been reduced to 30 per cent, and is generally satisfied by the transfer of the necessary number of shares in the new company.

The *modus operandi* obtaining in Rhodesia, and adopted by practically every financial house having an interest here, includes many features which, to those unacquainted with the local conditions and the market considerations, would appear to cast an unnecessary burden of heavy capitalization upon the mines; but there are explanatory circumstances. A mining claim in Rhodesia embraces an area 150 ft. along the strike of the outcrop or old working, by 600 ft.; hence ten claims constitute a block 1,500 ft. by 600 ft., which is equal to the mining claim as defined by the United States Mineral Code. The other regulations contained in the Mineral Ordinance are really only modifications of the United States laws. What is termed the "parent company" in Rhodesia is a limited liability company, with a capital of from $150,000 to $5,000,000, formed for the purpose of acquiring mines, lands, farms, etc., the latter being necessary in order to secure timber. At the present time the timber constitutes the only fuel of the country; the mining company pays a royalty of $1.20 per cord to the farm-owner The number of claims controlled by these parent companies varies from 100, in small concerns, to as many as 5,000 in the larger companies. The object of the parent company is to carry out a system of prospecting and

development work, with a view to placing independent properties upon the market. It is obvious that, in a country where development expenses are very high, there must be a limit to these operations, for if an attempt is made by the parent company to develop from 18 months' to two years' supply of ore, upon a number of claims, it becomes impossible to finance the work; hence it is clear that the gold-mining company must assume big responsibilities, and therein lies the key to many failures. The problems with which the parent company is faced are as follows:

(a) Capital and shares involved in purchase of property.

(b) Capital involved in prospecting and development work.

(c) Capital involved in installation of temporary surface equipment.

(d) Interest accumulating upon capital invested

The chief considerations of the gold-mining company are as follows:

(1) Capital involved in purchase of property from the parent company

(2) Capital involved in development work.

(3) Capital or shares involved in commutation of Chartered Company's rights.

(4) Capital involved in purchase and erection of plant.

(5) Capital or shares involved in making provision for possible extension of plant.

Assuming a width of vein of 30 in., with the ore-bodies not too scattered, it becomes necessary to make provision for an expenditure of no less than $360,000, in order to bring a property to a milling stage and equip it with a 20-stamp mill, cyanide plant, etc. This should, under ordinary circumstances, give 18 to 20 months' run of pay-ore. As a matter of fact, no mine in this country should commence the reduction of ore with less than three years' ore in such a state of exposure as to be reasonably counted upon to return a margin over and above the estimated working expenses; for it is next to impossible to keep the development work as far ahead of the reduction plant as the constantly fluctuating and inefficient labor-supply demands.

Assay Plans —At most of those mines, which have reached an advanced stage of development, surface and assay plans, as well as section and stoping plans, are kept; while the data embodied in the plans vary somewhat for different mines, the fundamental

principles are adhered to. The development assays as well as the stope-assays are taken at intervals of 5 ft, and plotted weekly. The pennyweights are shown in red and the width in inches in black All samples are taken over the actual reef-width, which figures are adjusted to an assumed stoping-width in the assay-book

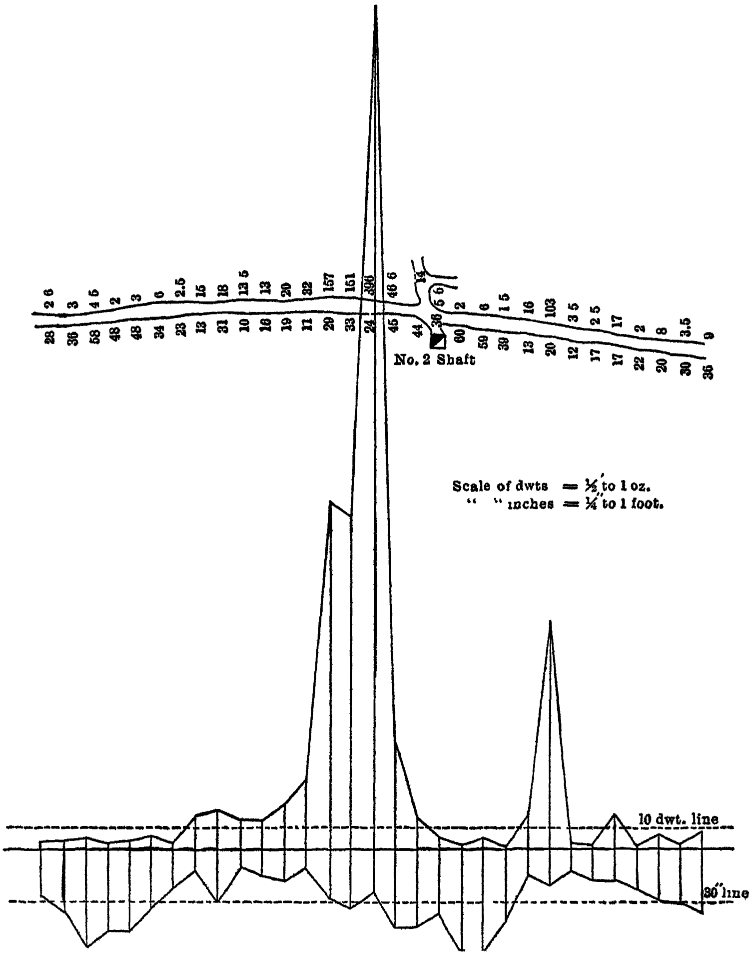
In the opinion of the writer, the methods (often used when the width of reef is under an assumed stoping-width) of sampling over the stoping-width, embracing both reef and country matter, are liable to produce inaccurate results It appears clear that where the character, hardness of the rock, etc., show a marked difference, it is almost impossible to obtain such a correct proportion of each section as to insure reliable results. These remarks are particularly applicable to this region, where so many small but rich veins occur, which, in many cases, have lent themselves more readily to oxidation than the enclosing rock. Sectional sampling is largely practiced, not only in development work, but at all stope-breasts, in order to avoid the handling of ore which will not leave a margin over mining and milling expenses. In this country the unit of value is the troy pennyweight, equal to about 4 shillings, or one dollar. In order that immediate approximations may be made of the stope-breasts, daily samples are taken and panned, these furnish, after one has become familiar with the character of the gold, etc., satisfactory results; but the results plotted always refer to fire-assays.

For the purpose of avoiding inaccuracies, the individual stopes are plotted to large scale upon separate blocks, and these are used for calculating tonnages. The usual scale for underground general plans, etc., varies from 1 in. = 20 ft. to 1 in. = 60 ft., depending upon the extent of the property.

Development Work. — Generally speaking, the quartz veins in this country may be said to be narrow. The lateral continuity varies greatly, and rarely exceeds the full length of a block (1,500 ft), the grade (when the widths are adjusted to a common basis and suitable areas are used in calculations) ranges between 8 dwt. and 22 dwt. per ton.

At the Wanderer mine, where a dry-crushing plant of about 300-ton capacity has recently been erected, the average is under 5 dwt. per ton; in this instance no underground work is necessary, the ore being quarried. In common with other countries where

the industry is only emerging from infancy, Rhodesian ventures have suffered by the erection of reduction plants before sufficient work has been accomplished underground. The period consumed in reaching the milling stage varies, of course, with the width



and lateral continuity of the reef in each case, but it may be said that in Rhodesia it requires from three to four years from the date that work is initiated.

The comparative cost of unskilled labor would suggest, at first sight, that the costs of development work should be very low;

this is not the case, however, for although the native wage seems low, when the other expenses incident to their employment are considered, it is found that they account for about 30 per cent of the total cost This is not clearly reflected in the figures following, as in this case the contract system is largely employed. The costs of stores, mining material, etc, together with many other incidental charges associated with mining in this country, as well as administrative expenses, are very high. It is therefore essential that large footages be obtained, so that a reasonable distribution may be made of the "constants." An analysis of the costs of development upon a Rhodesian mine is given herewith:

MINE DEVELOPMENT.

	Total cost	Cost per ton milled, cents	Percentage of total cost.
Salaries	$1,692 28	4.44	2.47
White wages	2,611 68	6 86	3.83
Contractors	21,882 74	57 50	32 03
Native wages	3,176 40	8 34	4.15
Native food	1,080.00	2 84	1 58
Stores	2,666 20	7 00	3.90
Maintenance	759 50	2 00	1.11
Workshops	1,046 86	2 74	1.53
Native hospital .	287 14	0 74	0.42
Native labor supply .	74 40	0.18	0 10
Pumping .	4,439.52	11 66	6 50
Compound	864 08	2 26	1.27
Compressors and rock-drills	16,399 74	43 08	24 00
Winding	1,605 16	4 22	2 35
Underground tramming . .	2,731 50	7.18	3 99
Assay account	690.94	1 80	1 01
Surveying and sampling .	712 70	1 86	1 04
Rock-drills and sharpening	5,579 28	14 66	8 17
Total .	$68,300 12	179 36	99 45

The footage executed during the period covered by this expenditure amounted to 2,677, representing a cost of $26.50 per foot.

With hand labor, driving in fairly hard ground, 40 ft. per month is considered good work, while with machine-drills 80 ft. is an average. On the Rand, anything up to 200 ft. per month is made in driving; in shaft-sinking also this rate is attained. Upon one property with which the writer was connected in the Transvaal about six years ago, no less than 260 ft. of sinking was

accomplished during one month, *i. e.*, from the 1,027-ft. level to the 1,287-ft. level

The smaller amount of work accomplished in this country is due largely to the inferior equipment, both underground and on the surface, for handling large quantities of broken rock.

Working Expenses. — I believe that, in Rhodesia, the requirements of an engineer, in respect to the number of properties he is expected to manage, are unusual It is therefore necessary that detailed and complete records be kept. The comparatively high and constantly fluctuating prices of mining materials and supplies make it essential that constant quotations of these articles be obtained and filed for daily reference, with the hope of effecting economy in operating expenses, as well as for the purpose of getting out estimates which can be treated with confidence.

This also suggests the importance of correctly measuring the tonnages handled. The methods in vogue are not conducive to accurate results; it is customary to count the cars of certain calculated capacity as they are delivered to the mill or crusher-station; this, less the number of cars discarded as waste (in all cases estimating 20 cu. ft. of broken rock = 1 ton), is taken as the tonnage crushed. It is apparent that greater care is required before a comprehensive comparison can be made of theoretical and actual results. The above methods would be all right, if, after determining the number of cubic feet to the ton in individual cases, each car delivered to the mill was of exactly the same capacity and filled to the same point, and moisture samples taken. This, however, is not practicable. The stope measurements, in some cases, are used as a check, but it is hardly necessary to state that only an approximation is arrived at. This matter is of great importance, both as regards relative working costs as well as relative stamp-duty, therefore, it is imperative that a uniform system be adopted, at least in cases where the figures are to be filed for record and general information.

Scales should be used for automatically weighing and registering the cars delivered. Then, if each car is tared and periodic moisture-samples are taken of the ore, as delivered, a correct idea of the tonnage will be obtained.

Milling. — The introduction of heavy stamps with the object of securing a large stamp-duty seems to have reached its practical limits, that is, at 1,456 lb. In Africa the mill is used more

as a crushing machine than with the idea of effecting perfect amalgamation, and so long as the ores lend themselves readily to subsequent treatment by cyanide in the state of fineness produced by the use of a low discharge and a coarse screen (20 to 25-mesh), a high duty is well enough. The prevailing method of operating a stamp-mill, in so far as the mechanical end of the work is concerned, is as follows: Order of drop, 1-3-5-2-4; height of drop, 8 in.; number of drops per minute, 96.

As a further means of increasing the stamp-duty, double crushing with rock-breakers is resorted to; the product being fed to the mill is crushed in the first case to about a 2.5-in. ring, and then passed to No. 2 crusher, where it is reduced to about a 1-in. ring. This method might be economically extended to three courses of crushing before being fed to the battery.

That most important branch of the work, namely, sorting, is almost entirely neglected in Rhodesian mines, and I daresay many tons of rock are sent through the mill which would not pay for the wear and tear that they are responsible for. Over a period of 12 months, with rock-breaking capacity sufficient to reduce the product to a 2-in. ring before entering the mill, an average duty of 5.5 tons per stamp per 24 hours has been obtained with 1,265-lb. stamps (an effective weight of 1,150 lb.), using a 2.5-in. discharge, 20-mesh screen, and the mill running at 96 eight-inch drops per minute.

It is well known that a stamp-mill under ordinary conditions does a large amount of unnecessary work, that is to say, the product, when it has been reduced to the fineness indicated by the screen, is not immediately discharged; hence a large percentage of the ore is reduced to a much finer state of division than there is (from a crushing point of view) any necessity for. In recent years a great deal of attention has been given to this subject, with the result that there are now on the market several classes of subsidiary crushers for use in connection with the stamp-mill. As an illustration of the product furnished from a stamp-battery, it may be stated that the writer has found, when using a 10-mesh screen, that 87 per cent of the discharged product will pass through a 30-mesh screen, and a duty per stamp (of 1,150 lb.) of nearly 10 tons is obtained, with ordinarily hard quartz.

Cyanidation. — Generally speaking, the ores of Rhodesia present few difficulties in metallurgical treatment. In most cases

the veins produce a typical free-milling ore, at the mills with which the writer is connected the richest tailing contains 3 dwt. per ton, from an ore carrying 14 dwt to 16 dwt. per ton. If the mill were operated with a view to high plate-extraction, and the tonnage sacrificed, the grade of tailing would be even less. The sand, if fresh, lends itself readily to cyanide treatment at a low cost per ton, while, if highly oxidized, as is often the case when working in close proximity to the ancient workings, a small additional cost is incurred in neutralizing

The construction of the double-treatment cyanide plant in use in this country presents no new features, and embraces the usual appliances necessary with zinc precipitation. The time of treatment varies with different ores, according to the character of the gold. In one instance the gold appears to be coated with a very thin film of iron sulphide and will not readily amalgamate, numerous coarse particles are contained in the tailing, and as much as 10 to 12 days are required to obtain a good extraction, although the usual treatment covers three to four days only

A great variation is shown in the fineness of the gold produced from cyanide slime; this is largely due to the fluxes used, or the preliminary method of treatment, it is quite possible, and not expensive, to produce gold as fine as 900 by using the following flux: Gold slime, 100 parts; fused borax, 20 to 35; manganese dioxide, 20 to 40; sand, 15 to 40 parts. This is a modification of what we call Crosse's flux at Johannesburg. The exact proportion of borax, manganese dioxide and sand is best determined by practical tests; sometimes fluorspar (about 5 parts) is used.

The addition of a cyanide plant in a country of free-milling ores may be questioned, but it is contended that if the grade of tailing in the first case will pay for treatment, it is a distinct advantage to cyanide because of the increased capacity of the mill

Gold Returns. — At the present time all declarations of gold output from the several producing mines are made in bullion.

The Mining Ordinance in Rhodesia demands that affidavits shall be made to the government, covering the actual amount of gold recovered monthly, by the individual companies, as well as by private enterprise. Hence, after each clean-up a declaration of this nature is made. The same form is requested by the local Chamber of Mines, the latter organization publishing the returns.

Unfortunately the unit used is the bullion ounce, which may vary from 700 to 950 fine It is obvious, therefore, that to make any comparisons without being in possession of the figures giving the exact fineness of the gold is a waste of time. In cyanide gold the discrepancies are even greater, the fineness varying from 250 to 750. The elasticity attending this method of dealing with gold is very great, and could be utilized for purposes of much graver importance than appears on the face of it. It would be far better to obliterate the troy measure altogether, substituting shillings and decimals of shillings, rather than to continue the use of a method so devoid of meaning.

The monthly production of gold (or bullion) from Rhodesia has reached 23,570 oz. There are two or three large mills under construction, which will add to the production of next year. With this increase and the introduction of a constant supply of Asiatic labor, the probabilities are that an output of 40,000 oz. will be reached within a year or so.

MINE LABOR AND COSTS ON THE WITWATERSRAND

By T. Lane Carter

(December 31, 1903)

The scarcity of Kaffir labor on the Rand has made for efficiency in its use, so that to-day the native workers are handled more skillfully than in ante-bellum days. At one time too many Kaffirs were allowed for a job, whereas now the number is cut to the lowest point. For instance, in 1899 machine drillmen were allowed six natives to run two rock drills. Now the work is done by five Kaffirs. The limit of efficiency with Kaffirs is soon reached because of their refusal to respond to the contract system.

The following figures from a large gold mine, of working costs during a month before the war, and of a month after the war, are of interest:

	In May, 1899	In June, 1903
Total number of Kaffirs at work	2,304	1,156
Average number of sick and idle	462	107
Cost of recruiting a Kaffir	£2 16s. 4d.	£2 12s. 3d.
Average wages earned per native per shift . .	£0 1s. 8.701d	£0 1s. 8.691d.
Average cost per ton of ore broken in stopes by machines .	£0 7s. 10.688d	£0 6s. 9 02d.
Average cost by hand stoping (Kaffir drillers) .	20s. (about)	£0 11s. 1.712d.
Average number of tons shoveled per native per shift	2,164	2,246
Average number of tons ore broken per machine per shift .	8,196	8,626
Width of stopes in inches .	55 in.	55 in
Working costs, inclusive of development and head-office charges, per ton milled:		
Mining (including all development or development-redemption charges)	£0 15s. 7.854d.	£0 11s. 1 224d.
Surface transportation	6 555d.	3.258d.
Sorting and crushing . .	4 954d.	2 171d.
Milling . .	2s 7.837d.	2s 2 475d.
Cyaniding .	2s 9 841d.	3s 6 380d.
General	1s. 9.841d.	1s. 5.630d.
Total cost per ton	£1 3s 1.452d.	£0 18s 9 138d.

The number of Kaffirs required to run present erected stamps, on basis of milling 348 days per annum, and maintaining ore reserves, is 2,500

It will be noted that there is practically no saving in Kaffir wages. The wage has gradually come up to what it was before the war

The most interesting figures deal with the comparative cost of stoping by hand power and machine drills. The figure as given was not accurately determined for this month, and is therefore approximate. It has frequently been maintained that, on the Rand, ore can be broken in stopes cheaper by hand labor than by rock drills. These data prove the contrary; true, the tonnage broken by hand power in June, 1903, was small, and the cost would be less with a greater number at work, but these figures, and the figures of other mines, prove that it would be uneconomical to substitute hand labor entirely for machine drills.

In stopes of 5 ft. or more, machines are preferable. The proposition is different when the reef is, say, 12 in. wide, and it is desired to keep the stoping width narrow. By hand drilling a stope can be carried 20 in. wide. Put a rock drill in the stope, and in most cases the width will go up to 40 in. With hammers, the cost of breaking ore in the 20-in. stope would be higher than in the 40-in. stope, but in the narrow stope the assay value of the ore trammed to the shaft would be nearly twice as high as in the 40-in. stope. This question of "hand drillers versus machine drills" in stopes is a vital one for every mine on the Rand. Each stope should be made a separate study, before deciding to work it with hammers or machines.

It will be seen that the greatest reduction in costs has been under the head of mining. This is due principally to two causes: (1) Cheaper dynamite; (2) labor-saving devices underground.

As regards the efficiency and cost of white labor, there is little change. As far as development work is concerned, the standard is not as high as it was previous to the war. The impression has gained ground that in development work there is more danger from miners' phthisis, and the men are, therefore, shy of the work. A stoper can earn as much as a driver, and has less risks; hence the bid for the stopes. It may become necessary to arrange prices so that the man who drives, raises or sinks can earn more money than the man in the stope.

The employment of white unskilled labor on these fields on a large scale is now practically abandoned. The experiment was a failure. Take these figures from a big mine:

Rate per shift to unskilled white labor, excluding food .	5s 8 715d	
Rate, including food	8s 7.622d	
Average number of natives displaced by one white man (for this mine only, which is above the average).	$1\frac{3}{4}$	
Total increase in working costs and capital expenditure in period (a few months) if all natives had been replaced by unskilled white labor. . .		£36,946

It is said that there are at present 2,000 men out of employment on the Rand. To help this body of men, the government, which runs the railroads, is offering to take on unskilled whites at $2 per day.

Quite a number of the unskilled whites were employed as helpers on rock drills. After a few months' experience they obtained blasting certificates, and as far as the mining regulations are concerned, were the equals of men who had been mining for years. These men went to other mines, showed their blasting certificates, and were set at work on rock drills. Needless to say, they were not expert. A first-class rock-drill man does not learn his trade in two months.

Of the large number of unemployed, it is safe to say that only a small percentage are really skilled men. The big majority are either without a trade, or "wasters." This is the cruelest place on earth for both classes. First-class rock-drill men are hard to get. Eighteen months ago it was made known in America and England that 200 skilled rock-drill men were wanted at a minimum wage of £1 per day. For that guarantee 70 or 80 men only have been obtained. Quite recently, arrangements were made to get out 70 Italian miners from the Simplon tunnel. Some of these have already arrived.

It will be seen that something will have to be done to meet any big demand for skilled rock-drill men in the future. It is my opinion that the outside world can only partially supply the demand. Therefore a percentage will have to be trained on the Rand. This has been, and is being, tried; but it is difficult. As intimated above, the learner gets a blasting certificate in two months' time, and passes as a skilled driller. He is a machine

man, possibly, but a very inefficient one, expensive to the company at any price.

A possible way out of the difficulty would be to have different grades of certificates, making it compulsory for a learner to serve at least a year on machine drills before he is passed as a skilled driller.

MINING COSTS AT CRIPPLE CREEK

(January 14, 1904)

The Editor

SIR—Mr. Finlay's interesting communication (in the JOURNAL of November 21) calls attention to an important and much neglected field of discussion. If detailed figures of mining costs were more generally available there would be less misdirected effort in mining. It is often assumed that such figures are of interest only to the mining engineer, to enable him to check his own work against that of others. Their most important value is, however, to the investing public. If such figures were more generally published, it would be less easy for an unscrupulous promoter to impose on the inexperienced; and there would be a better apportioning of credit to deserving mine managers. Probably all visitors to mining regions have been impressed with the number of idle properties which, on inquiry, are found to be idle because of lack of working capital. It is the old story of costs underestimated, of a scale of work unsuited to the character or size of the orebody, and of waste and fruitless effort. The projectors of the various enterprises have usually had utterly erroneous ideas of the cost of the work, and disaster has been the result. Again, it has, unfortunately, happened to many mining engineers that their best efforts were thwarted by lack of appreciation of the significance of figures presented, on the part of their own board of directors. In the case cited by Mr. Finlay the fact that low mining costs are not the only desiderata is excellently shown. It is easy on the other hand to call to mind dividends paid by reason of the richness of the orebody, even despite the absence of any skill in actual management.

It should be the purpose of all interested in the mineral industries to promote the economical and efficient development of our natural resources, and certainly the frank discussion of costs is as essential to this, as discussion of methods of work. However desirable it may be to have complete cost records, and I heartily

endorse Mr. Finlay's position in the matter, it is not always practicable to do so; and many engineers hesitate to give out incomplete information for fear of its being misleading. This is a real danger properly to be guarded against; but even incomplete figures, carefully stated and analyzed, may carry their lesson without promoting misconceptions.

These considerations shall be my excuse for presenting the following partial figures of the cost of mining 7,087 tons of average Cripple Creek ore. The cost per ton was $14.73, of which $9 06 was for labor and $5.67 for supplies and all other costs. In mining the ore 388,725 cu. ft. of stoping was done, equivalent to 54.8 cu. ft. per ton of ore sold. The development work consisted of 1,416 ft. of drifting and 100 ft. of sinking. At the beginning and end of the campaign the ore-reserves were approximately equal, if not somewhat increased. This accordingly represents roughly the amount of development work necessary to keep the mine alive. If this development work be figured in cubic feet, then 56,208 cu. ft. of crude ore and waste must be added to that taken from the stopes; or, for every ton of ore sold, 54.8 cu. ft. was stoped and 7 9 cu. ft removed in development. The work was done with small machine drills, the average of stoping being in the ratio of 120 cu. ft. per machine per shift. This ore was all screened and hand-sorted, so that the 7,087 tons sold were really concentrated from the 34,759 tons broken and handled.

If the costs be figured on the basis of this crude ore instead of the concentrated ore, as is customary in other districts, the cost figures become: Labor cost, $1.84; supplies and general, $1.16; total, $3. Of the total cost, approximately $2.60 was mining cost and 40c. was for development. This method of figuring the development cost back to the tons sold is unusual but has advantages where, as in the present case, it becomes possible. If in a given campaign the ore-reserves were notably depleted or increased, it would be difficult, if not impossible.

Even when the costs are reduced to terms of crude ore and waste broken, Cripple Creek costs are high in comparison with those elsewhere. This is due in part to high labor and in part to the smallness of the orebodies, which necessitates the handling of much waste. In the present case the average daily wage was $3.57 for an eight-hour shift, less 20 minutes for lunch and about

10 minutes at changing time. The figures are higher than Mr. Finlay's average, presumably because a larger proportion of machine-men were employed. Coal also averaged higher than in the case cited by him, though timber was about the same. An effort was made to decrease costs by increasing the capacity, and it was found that this decreased the item of labor, but not the supplies. The record of two separate months is given below:

Tons sold	Labor cost	Supplies and general expenses	Total
1,011	$11 02	$4 12	$15 14
1,873	8 05	4 99	13 04

Not much reliance is to be placed on these figures, however, in view of the small tonnage and the considerable difference in costs resulting from variation in the amount of development work carried on. The particular months given were chosen with a view to eliminating these factors as far as possible. Comparisons made between these figures and the costs, at a number of still smaller mines under the same management, indicate that the labor cost per ton is not influenced much by the scale of operations up to a monthly output of 1,000 tons. Comparisons with costs at plants having still larger outputs indicate roughly that the cost per ton shipped is influenced more by the character of the ore-body than the scale of operations.

H. Foster Bain.

Washington, D. C., Dec. 18, 1903.

MINING AND MILLING IN THE MOJAVE DESERT

(January 28, 1904)

The Editor

SIR—The Desert region, from an economic standpoint, in regard to mining, has a number of disadvantages that militate against the profitable extraction and reduction of low-grade ore, as compared with more favored localities The scarcity of water, fuel and timber, and, in some cases, an entire absence of the same, increases the cost of mining and reduction to such an extent as to render the mining and reduction of low-grade ores unremunerative. The last-named conditions obtain at Randsburg, Kern county, California. In the accompanying table from the monthly report of the Yellow Aster Mining & Milling Company it will be seen that low-grade ore, from $3.50 up, can be made to yield a good profit, under proper conditions. The above-mentioned mine is equipped with two mills, one of 100 and the other of 30 stamps, reducing 500 tons of ore a day on an average. Although within a distance of two miles of the terminus of the railway, freights are high, as will be seen from the prices of supplies, a few of the important ones being appended herewith:

Fuel oil, 4½c. per gal.; lumber, $32.50 per thousand; other supplies in proportion. Water is obtained from two wells, sunk to the depth of 450 and 300 ft., respectively, at a mean distance of six miles from mine and mill, at a point 1,500 ft. below point of delivery. On account of the strike declared against the company on June 10, 1903, the mine remained closed until September 1 following. Since that date the mine has been in operation steadily to its full capacity, with non-union employees.

The following is the scale of wages: Miners, 9 hours, $3; muckers, 9 hours, $2.50; car-men, 9 hours, $3; timber-men, 9 hours, $3.50; amalgamators, 12 hours, $4; stationary engineers, 12 hours, $4; hoisting engineers, 8 hours, $3.50; pump-men, 12 hours, $3.50.

EUGENE H. BARTON.

Randsburg, Cal, Dec. 15, 1903

YELLOW ASTER MINE

14,601 Tons Treated   From November 1 to December 1, 1903 { Total disbursements $30,183 96; Total cost per ton 2,067 00 }

	Total Expenditure	Expenditure	Per Ton	Remarks
Ore extraction	$17,656 40			
Labor		$10,696 69	$0 73260	Miners, muckers and carmen
Timbering		803 55	0 05500	Timbermen, framers and assistants
Timber		2,661 47	0 18228	8 by 8, 6 by 8, 2 by 12, Oregon pine
Powder		580 68	0 03977	
Fuse		93 90	0 00643	
Caps		44 97	0 00308	
Lights		306 62	0 02100	Candles, electric and oil
Blacksmithing		498 32	0 03414	Tool-dressing, horseshoeing, car repairs, etc
Development		628 72	0 04306	Hoisting, training and incidentals
Haulage		643 90	0 04410	Drivers, mules, feed, etc
Hoisting		697 92	0 04780	Tons hoisted, 6,900, cost per ton, $0 1012
		$17,656 40	$1 16620	
Milling	$5,981 69			
Power		3,340 70	0 22880	Attendance, fuel and maintenance, etc
Labor		1,123 40	0 07694	Amalgamators, foreman, etc
Rock-breaker		674 67	0 04620	Attendance, repairs, etc
Shoes and dies		535 79	0 03690	
Repairs		256 53	0 01757	General repairs
Mercury		47 60	0 00326	0 0815 oz loss per ton
		$5,981 69	$0 40967	
Water	$3,220 09	3,220 09	0 22053	Pumped 6½ miles against 700 lb pressure, at a cost of 19c per 1,000 gal
		$3,220 09	$0 22053	
General expenses	$3,325 83			
Miscellaneous		1,460 10	0 10000	Taxes, insurance, expressage, etc
Assaying		160 61	0 01100	Assayer, fluxes, fuel, etc
Salaries		950 87	0 06507	Superintendence, engineering, etc
Tailing		313 33	0 02146	Impounding tailing and water
Incidentals		440 92	0 03020	Telegraphing, legal and office expenses, etc
	$30,183 96	$3,325 83	$0 22773	

COST OF MINING ZINC ORE IN THE JOPLIN DISTRICT

(February 25, 1904)

The Editor:

SIR—Your reviews of the lead and zinc production and the Joplin district in your issues of January 7 and 14, and the discussions in more recent issues, have attracted my attention. The views expressed as to the cost of mining zinc ore in the Joplin district recall a problem which presented itself to me about a year ago.

Naturally enough, it is popular among the mine operators to refer the cost of mining to units of the product sold. A statement like the following is very simple and easily understood: Zinc ore sells for $34, the cost of mining and royalty amounts to $28, and the profit is, therefore, $6 per ton of zinc ore. This method of calculation may not be objectionable as applied to a particular mine producing ore of uniform richness, but it is readily shown that to generalize with such estimates of cost may be very misleading.

It costs practically the same to mine and mill material yielding 5 per cent of clean zinc ore as it does if the mine-run ore yields 10 per cent, but the operating cost referred to a ton of product in the former case is about double. The royalty charges, on the other hand, are a definite percentage of the receipts from ore sales, and are, therefore, proportional to the selling price and amount of clean zinc ore produced. The determination of the cost of production of a ton of zinc ore may be further complicated when a considerable part of the product of the mine is lead ore. The price of both lead and zinc ore are subject to changes from week to week, and are possibly chargeable also with different rates of royalty.

The table given herewith was calculated to meet just such a problem under conditions where the margin of profit was small, and likely to be altogether wiped out by a drop of a few dollars in the price of either lead or zinc ore. The mine-run showed

TABLE OF NET CASH RECEIPTS PER TON OF ORE HOISTED AND MILLED AFTER PAYING 10% ROYALTY. YIELD OF ORE ASSUMED AT 2 3% JACK (BLENDE) AND 1 1% LEAD (GALENA)

Jack price per ton	Lead price per M $20	Lead price per M $21	Lead price per M $22	Lead price per M $23	Lead price per M $24	Lead price per M $25	Lead price per M $26	Lead price per M $27	Lead price per M $28	Lead price per M $29	Lead price per M $30
$15	$0 707	$0 727	$0 747	$0 766	$0 786	$0 806	$0 826	$0 846	$0 865	$0 885	$0 905
16	0 727	0.747	0.767	0 786	0 806	0 826	0 846	0 866	0 885	0 905	0 925
17	0 747	0 767	0 788	0 807	0 827	0 847	0 867	0 887	0 906	0 926	0 946
18	0 769	0 789	0 809	0 828	0 848	0 868	0 888	0 907	0 927	0 947	0 967
19	0 789	0 809	0 829	0 848	0 868	0 888	0 908	0 928	0 947	0 967	0 987
20	0 810	0 830	0 850	0 869	0 889	0 909	0 929	0 949	0 968	0 988	1 008
21	0 831	0 851	0 871	0 890	0 910	0 930	0 950	0 970	0 989	1 009	1 028
22	0 851	0 871	0 891	0 910	0 930	0 950	0 970	0 990	1 009	1 029	1 049
23	0 872	0 892	0.912	0 931	0 951	0 971	0 991	1 011	1 030	1 050	1 070
24	0 893	0 913	0 933	0 952	0 972	0 992	1 012	1 032	1 051	1 071	1 091
25	0.913	0 933	0 953	0 972	0 992	1 012	1 032	1 052	1 071	1 091	1 111
26	0.934	0 953	0 974	0 993	1 013	1 033	1 053	1 073	1 092	1 112	1 132
27	0.955	0 974	0 995	1 014	1 034	1 054	1 074	1 094	1 113	1 132	1 152
28	0.975	0 995	1 015	1 034	1 054	1 074	1 094	1 114	1 133	1 153	1 173
29	0 996	1 016	1 036	1 055	1 075	1 095	1 115	1 135	1 154	1.174	1 194
30	1 017	1 037	1.057	1 076	1 096	1 116	1 136	1 156	1 175	1 195	1 215
31	1 038	1 058	1 078	1 097	1 117	1 137	1 157	1 177	1 196	1 216	1 236
32	1 058	1 078	1 098	1 117	1 137	1 157	1 177	1 197	1 216	1 236	1 256
33	1.079	1.099	1 119	1 138	1 158	1 178	1 198	1 218	1 237	1 257	1 277
34.	1 100	1 120	1 140	1 159	1 179	1 199	1 219	1 239	1 258	1 278	1 298
35.	1 120	1 140	1.160	1 179	1 199	1 219	1 239	1 259	1 278	1 298	1 318

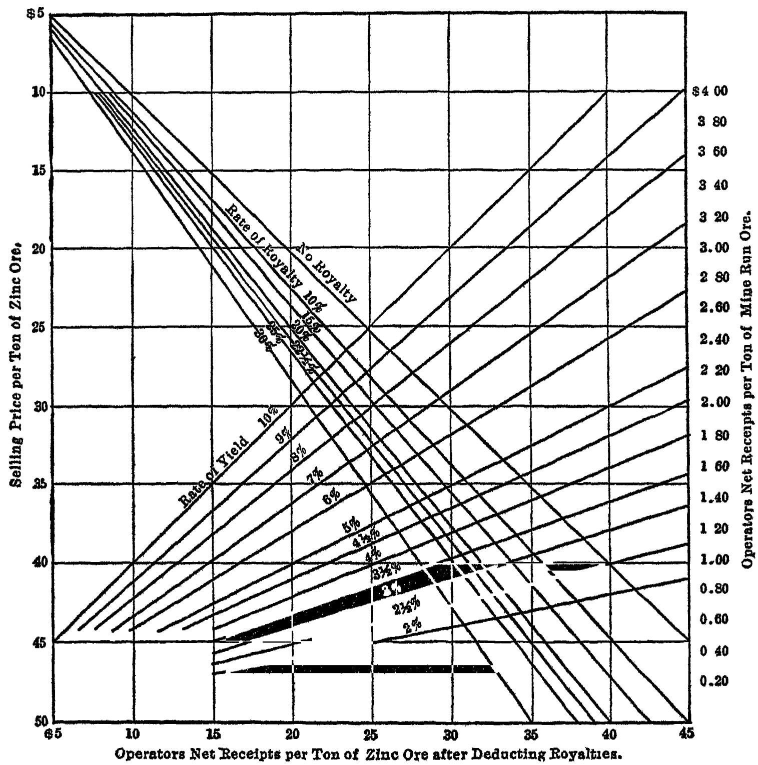
a very uniform yield of 2.3 per cent zinc ore and 1 1 per cent lead ore, calculated from the results of milling 12,277 tons. Although the yield varied fractionally from day to day, the average for any month did not vary more than 0.1 per cent from that adopted in the preparation of the table; the figures represent the calculated net cash yield per ton of mine-run after the payment of the royalty. Out of these amounts the cost of mining and milling is to be paid.

The use of the table may be illustrated by an example: Assume that zinc ore is selling on a $28 basis for 60 per cent ore; that the ore contains some iron, and must pay a penalty of $2 per ton, fetching, therefore, $26 per ton in the bin, and that lead ore sells for $25 per thousand pounds in the bin. Under these conditions a reference to the table shows the net cash receipts to be equivalent to $1.033 per ton, and, if the operating expense is $1 per ton, the margin of profit is 3 3c. per ton of ore mined and milled. Should zinc ore prices decline $2 per ton, then receipts would fall to $0.992 per ton, and the mine would show a small loss. Since the cost of mining is given by our books, a reference to this table affords, at once, the data for an accurate estimate of prospective gains or losses under ruling current prices for lead and zinc ores, and makes prompt action certain, if changes in prices demand it.

The table is useful only for the particular combination of yield and royalty assumed, but a similar table may be prepared to represent any other combination of conditions. When a mine produces zinc ore alone, or lead ore alone, the problem of determining costs is simpler and lends itself very nicely to representation by a diagram. Such a diagram for zinc ore is presented herewith.

The selling price per ton of ore is represented on the vertical scale at the left of the diagram, the rates of royalty are represented by one set of diagonal lines, and the rates of yield of clean zinc ore, expressed in per cents of mine-run, are represented by another set of diagonal lines. The horizontal scale at the bottom shows the operators' net receipts per ton from the sale of the zinc ore, after deducting royalty, and the vertical scale at the right expresses the operators' net receipts per ton of mine run for any combination of prices, royalty and rate of yield. Out of these amounts, the operator is to pay his working costs and

make his profit The use of the diagram is explained by two examples, one wherein the net receipts per ton of mine-run are determined for an assumed combination of price, royalty and yield; and the other in which the working costs, royalty and yield being assumed, the selling price is determined at which costs and



COST DIAGRAM FOR JOPLIN ZINC ORES.

receipts would just balance. If the mine yields both lead and zinc, the net receipts per ton of mine-run may be determined for each separately, preferably for convenience, by different diagrams, the sum of the two being the total receipts per ton. Values for lead ores may be shown on the same diagram, if desired; but since the relative yield of lead ores is often small, a different scale for the yield diagonals makes a more convenient and useful diagram.

Another use of the diagram is illustrated by the following example: Assume the selling price of zinc ore at $30, royalty 20

per cent, yield 5 per cent, operating costs $1 per ton of mine-run. Take $30 on the scale of selling prices at the left, and follow the horizontal line to the 20 per cent royalty-diagonal, then follow the intersecting vertical line to the bottom of the diagram, on which we read $24, which represents the operators' net receipts per ton of clean zinc ore sold, after deducting royalties. Now take $1, on the vertical scale at the right of the diagram, follow the horizontal line to the 5 per cent yield diagonal, then follow the intersecting vertical line to the bottom line, on which we read $20. This represents the working cost on clean zinc ore, and the profit must be, therefore, the difference between $24 and $20, namely, $4 per ton of zinc ore sold. This will be seen to correspond with the calculations in the first example on the diagram. Assuming that 100 tons of mine-run are handled daily, the product will be 5 tons of clean zinc ore, and the profit by the first method is figured on 100 tons of mine-run at 20c, namely, $20, and by the method just explained, the profit is on 5 tons of zinc ore at $4, or $20, as before.

The cost of mining and milling in the Joplin district varies from 80c. to $1 per ton of mine-run. This figure does not include any charge for redeeming the capital spent in opening up the mine and equipping it. When the ore-bodies are of considerable size, the mills of modern construction, and the operator has little or no pumping to do, these figures need seldom be exceeded, and in some cases costs may fall somewhat below the lesser figure. Between these limits, costs vary according to physical conditions, being high in hard sheet-ground, where air-drills must be employed, and the powder bills are large, and in soft ground, where the saving in the powder bills is offset by the cost of timber. Occasionally an operator is fortunate enough to have soft ore and a hard roof, and under such conditions the cost of mining and milling has been quoted as low as 75c. per ton.

Large areas of sheet-ground are now known in the Carterville Webb City district. Most mines in this sheet-ground vary in yield of zinc ore from 2.5 to 5 per cent, although, in some cases, they are very much richer. Adopting $1 per ton as a fair estimate of the cost of the mining and milling in this kind of ground, and referring to the diagram, we get the prices of ore at which the mines of different rate of yield will come into profitable production.

In making comparisons, the effect of quality on the selling price of zinc ore must be kept in mind, for, although the basis price for 60 per cent zinc ore may be $30 per ton, one mine may produce ore of so high a grade that it finds ready sale at $34, whereas another mine may produce ore containing mundic and will fetch, according to the assay, one or more dollars less than the basis price.

According to rate of royalty, from 10 to 25 per cent:
Ore yielding 5 per cent will pay, when the zinc ore sells at $22.20 to $26.70.
Ore yielding 4.5 per cent will pay, when the zinc ore sells at $24.70 to $29.70
Ore yielding 4 per cent will pay, when the zinc ore sells at $27.80 to $33.40.
Ore yielding 3.5 per cent will pay, when the zinc ore sells at $31.80 to $38.20.
Ore yielding 3 per cent will pay, when the zinc ore sells at $37.40 to $44.40.
Ore yielding 2.5 per cent will pay, when the zinc ore sells at $44.50 to $53.00 [1]
Ore yielding 2 per cent will pay, when the zinc ore sells at $55.00 to $67.00 [1]

The foregoing data serve to emphasize the fallacy which may develop by basing costs on the tonnage of zinc ore sold. The richer mines yielding 7 to 10 per cent and upward are exceptions among the general run of Joplin mines, and those which are running on ore leaner than 5 per cent doubtless constitute the majority. When ore prices advance beyond $25, the 4.5 per cent and 4 per cent mines start up; when prices go to $32 the 3.5 per cent mines begin to produce, and at $37 the 3 per cent mines are worked.

Each successive class offers to the market more expensive ore, and consequently the average cost of production for the entire district, referred to the cleaned zinc ore, seems to advance nearly in proportion to the advancing ore prices. The cost of mining per ton of mine-run remains, however, practically unchanged, except for the effect of changing prices of labor and supplies.

W. Spencer Hutchinson.

Boston, Feb. 1, 1904.

[1] Estimated because beyond the limits of the diagram.

MINING IN RHODESIA

(March 10, 1904)

The Editor

SIR—In your issue of December 10, 1903 (Vol. LXXVI, pp. 885–888), appears a very interesting and timely article on "Gold Mining in Rhodesia," by Mr. F. C. Roberts. It has an especial interest for me, for many of the data upon which the article is based have been furnished by a mine in which I am a shareholder, and of which the earlier development was carried on under my direction. Mr Roberts was for a short time the mine manager, and later succeeded me as engineer.

Having spent nearly six years in Rhodesia, and having had exceptional opportunities of studying a large portion of that section of it known as Matabeleland—and it is to this section that Mr. Roberts more particularly, though not exclusively, refers—I would like the opportunity of offering a little friendly criticism on the article referred to. In my remarks I shall keep in mind the fact that an article which attempts in such small compass to treat of every feature of the gold-mining industry in Rhodesia must necessarily be incomplete.

The first statement upon which I would comment is: "In but one instance in the whole of Rhodesia has it been found advantageous to attack the orebodies and veins through adits." If this means that only one adit has been driven in Rhodesia it is very wide of the truth I have seen adits on no fewer than seven different properties, and there are others in the country; and I have every reason to believe that it will be found advantageous to win the ore from more than one of these.

Physical and Geological Features. — While it is a fact that "few really high mountain ranges traverse the country" it must be borne in mind that the general elevation is high, Bulawayo being 4,469 ft. above sea-level, and the summits of the highest hills reach an elevation of nearly 6,000 ft. Viewed from the plains and valleys the hills certainly do not appear high.

I had not observed the feature of "conical hills" in the granite belts, though I have traversed the country from its eastern boundary as far west as 27° 20′ E long., and from its southern boundary as far north as 17° 40′ S. lat. The weathering of the granite hills in Rhodesia is the same as in other parts of the world, the prevailing types being either domes or boulder-strewn ridges with castellated escarpments. The conical hills (more correctly, pyramidal) are rather characteristic of the schistose areas

It is true that "no geological survey has yet been made in Rhodesia" (though in no other country in the world is one more needed), and the several so-called "geological" maps of it which have been published have no scientific value whatever; but the "generalized description" of the geology given by Mr. Roberts is not very accurate, if not actually misleading. Enough is known of the subject to afford a better account than has been presented by Mr. Roberts; but of course it must be understood that he writes as a miner rather than as a geologist.

We are told that "By far the greater portion of the country consists of granite rocks, in wide belts, having a strike somewhat west of north and east of south." Even if in the term "granite rocks" we include typical granite, syenite, gneiss, and all granitoid varieties of rocks, I think Mr. Roberts' estimate of the extent of their occurrence is an excessively high one. I should say that very much less than one-half the total area of the country is granitic. The strike of these rocks is not accurately given, indeed no general strike prevails. Some of the larger granite belts have a trend almost due east-and-west, some smaller ones trend north-and-south; and some in fact trend in almost every direction.

While it is true that "the gold belts embrace the areas characterized by slates and schists," it is also true that some of the gold mines are well within the granite areas. This is the case of a typical mine described,[1] the immediate country-rock being granitoid, and it lies on the northern side of an extensive granite belt, trending nearly east-and-west, and bounded on the north and south by hills of metamorphic rocks.

We are told that "In the valleys, or small gulches of the hill country, the alluvium is of very limited extent, suggesting a lack

[1] THE ENGINEERING AND MINING JOURNAL, p. 885, Dec. 10, 1903.

of those extreme climatic conditions necessary to produce rapid erosion." But even if it were true—which I take leave to doubt —that the alluvium is so limited, surely the fact suggests something else than that stated. Do not the torrential summer rains account for the removal of the alluvium from the hill country? In the broad valleys the thickness of the alluvium is often very great, and every one who has visited the country is familiar with the deep rifts by which the river-fords are usually approached.

The description of the quartz veins might have been extended by a reference to a number of large ones which are not only wide, but may be traced almost continuously for several miles. Reference is made to the auriferous diorite of the Ayrshire mine, but, as you point out in a footnote, this has been previously described in the JOURNAL at greater length. I am greatly interested in Mr. Roberts' account of his discovery of an auriferous hornblende porphyrite, and I wonder if it occurs in a part of the country which I visited.

Ancient Workings. — Some of those who have devoted much time to the study of the question of the ancient race, or races, who formerly exploited the Rhodesian goldfields, will hardly feel flattered on being told that " no satisfactory explanation has been advanced touching their (the ancients') identity," notwithstanding that ethnographical investigators have written volumes on the subject. But I am prepared to go all the way with Mr. Roberts when he speaks of the estimates that have been made of the gold recovered by the ancients as "hypothetic"—I think they are ridiculous; but I cannot believe with him that 10 dwt. of gold per ton of ore was the minimum value of that treated by the ancients—I think they must have, in many cases, treated ore as low as, if not lower than, 5 dwt. of gold to the ton.

Financial Considerations. — We have here a brief but fair account of the financing of Rhodesian mines, many of which, it may be emphasized, are very largely over-capitalized. In referring to the Mineral Ordinance, Mr. Roberts omitted to mention that a new one has been drawn up and is expected soon to be promulgated, and from which the objectionable feature of the "law of the apex" is to be eliminated. Mr. John Hays Hammond has been largely blamed—I know not with what truth—for the adoption of this indefensible feature of the original ordinance. But

as the new ordinance can hardly be made retroactive, it is likely that the lawyers may yet reap a golden harvest from the obnoxious law

Assay Plans. — Mr. Roberts' description of these as in use in Rhodesia is correct as far as it goes; and it is satisfactory to learn that while slight differences of method of constructing the plans may be found in the several mines, "the fundamental principles are adhered to." This general uniformity of principle may be largely attributable to Mr. E. H. Garthwaite, the government engineer, who has made a special study of sampling and mine-valuation, and has been in a position to impress his views on the companies' engineers. The assay diagram figured by Mr. Roberts[1] seems to me to have been unfortunately selected and inaccurately described. I do not think the use of graphic diagrams has yet become general in Rhodesia; nor is the one illustrated a "stoping diagram." I recognized it at once as a simple assay-plan of a prospecting level which was opened up under my direction in 1897–98. The suggestion that assay values should be given in shillings instead of troy pennyweights is most important, and it is to be hoped that this system may be adopted in the near future.

Development Work. — It is difficult to offer any criticism of the figures presented by Mr. Roberts, as they are incomplete and some minor errors appear. It would seem that in the period under review 2,677 ft. of development was accomplished, and 38,100 tons of ore were won and milled. Now, if the shafts, levels and winzes averaged 4 by 6 ft. in cross-section, and allowing 14 cu. ft. of quartz to the ton, there would only be 4,589 tons obtained from the footage given. Perhaps the decimal point in the middle column of figures is misplaced one figure to the left, in which case the tons milled would figure out about 3,810, and the total cost per ton milled would be $17.93 instead of $1.79, which would be absurd. What is probably the fact is the omission to mention the area stoped. But "stopage" is not "footage." If no stoping is included in the cost the price given per foot, $26.50 (it figures out $25.51), is excessive, even for Rhodesia. On the other hand, if the total cost of mining ore is only $1.79 per ton the figure seems too low. Putting the cost of milling—which is not given—at one-half that of mining, which is fair, the total cost

[1] THE ENGINEERING AND MINING JOURNAL, p. 886, Dec. 3, 1903.

per ton would only be $2 68, a figure that is too low for Mr. Roberts or anyone else to reach in Rhodesia.

Then the two items "Compressors and rock-drills" and "Rock-drills and sharpening" together amount to $21,979, out of a total of $68,300, or over 32 per cent. And here I might say that this seems to confirm my expressed opinion that at the mine in question, owing to the scarcity and high cost of fuel, the installation of a compressor plant was not advisable until cheaper fuel could be obtained. Possibly some part, or the whole, of the cost of the compressor plant is included in the item $16,399; if so, a portion at least of the cost of all the other plant should be included as well. It is not worth while to discuss these figures further until additional light is thrown upon them by their author.

Milling. — We are informed that "The introduction of heavy stamps with the object of securing a large stamp-duty has now reached its practical limits, that is, at 1,456 lb." Does not this weight exceed the limit? I fear so, and the fear is partly inspired by what Mr. Roberts says further on the subject. When I drew up the first specifications for the mill under review I called for stamps of 1,050 lb falling weight, but later, on consulting with some of the leading engineers at Johannesburg and Bulawayo, I altered the specification to 1,250 lb. But the mill was ultimately erected under Mr. Roberts' direction and, I presume, according to his specifications.

Cyanidation. — Mr. Roberts' remarks on this subject are interesting and important. It may be questioned, as he points out, whether it is advisable to instal a cyanide plant in Rhodesia so long as the ore continues free-milling. There would be no question of its advisability whenever the sulphide ore is reached. It is all a question of testing for each particular mine.

Perhaps I feel an exceptional interest in Mr. Roberts' article, dealing as it does with a mine of which the first development was done under my direction, but it should have a general interest as well, and it is only to be regretted that it was not longer and more detailed.

WALLACE BROAD.

Shanghai, Jan. 25, 1904

THE ECONOMIC RATIO OF TREATMENT CAPACITY TO ORE-RESERVES'

By H C. Hoover

(March 24, 1904)

Although every metal mine is a problem peculiar to itself to such an extent as to upset most generalizations, it will be not wholly useless to contemplate certain problems in the abstract. In various forms they confront every engineer, sooner or later, and although discussion involves much reiteration of elementary principles, yet there are so many mines in which even elementary matters of good management are continually disregarded as to warrant such repetition. The ensuing discussion applies mostly to that great majority of mines, the uncertainty of whose continuity in depth necessitates in every project of general policy a substantial margin of security against the unknown. Starting with an assumption of unbroken continuity to their utmost boundaries, our South African friends need but little outside of compound-interest tables upon which to found their finance. In the great majority of mines, however, the result of development at their lowest levels remains speculative and gives a zest such as an assumed persistence can never afford.

That the most economical and profitable treatment capacity is the maximum capacity which can be employed, is not difficult to demonstrate; that the maximum must depend, however, upon the speed of development, and that development must be pushed as fast as the limitations of nature will permit, is but to state a corollary. Yet, curious as it seems, the number of mines which have been operated upon the principle that the mill is the fixed quantity and the mine the variable, exceeds the number conducted upon the reverse plan The objective of development in this preponderating number is to feed the mill. This assertion is verified by the fact that while the majority of mines now in operation

are more than ten years old, nevertheless a minor number have reached a depth of over 2,000 ft. when they might, even in this comparatively short period, have attained a depth of 3,000 ft had they pursued the policy of development under highest pressure and the erection of treatment units such as would keep the ore-extraction close to such development.

It will be granted that the true objective of mining is to gain the greatest profit from a given body of ore. The maximum output is not only necessary for the cheapest production, but money locked up in ore underground is idle money, and the profits from mining can be increased in no mean degree by rendering it liquid. There are, however, limitations imposed upon the investment of large sums of money in equipment to secure the maximum output, in view of the uncertainty of continuity in depth, which need to be considered. In considering these limitations, and a method by which the economic ratio may be arrived at, it will be necessary to demonstrate the generally accepted proposal already laid down. The problem may be reduced to the question of conducting operations upon a given output as against a greater output, because few well managed mines of the character under discussion are, in their initial stages, equipped to their maximum possibilities—and certainly the great majority, as shown above, are not yet so equipped; therefore, the problem in actual practice presents itself either in the form of increasing the output, or determining originally some volume of output to be provided for, as against some smaller volume. We may call the initial treatment capacity the primary equipment, and the increased plant the secondary equipment. The factors in this problem are:

(1) The cost of production as affected by increased output.

(2) The redemption of capital invested in secondary equipment.

(3) Limitations imposed by the uncertainty of continuity in depth.

(1) The elaboration of accounts during the past has introduced to the engineer many complications of mining finance which did not trouble our forefathers. We now divide the various charges against working expenses into, first, those charges variable with tonnage (such as development, haulage, treatment, etc.); and second, those charges, usually referred to as "fixed," which depend partially upon the element of time as well as tonnage, and

include, partly or wholly, pumping, management, amortization[1] of capital invested, etc. Moreover, there is a factor of no mean importance arising from the loss of interest through idle profits locked up in ore standing in the mine; this also must be taken into account.

From the standpoint of such "fixed charges" as depend partially upon the element of time, obviously the shorter the period involved in the extraction of the ore the better. The introduction of increased equipment necessarily shortens the time of extraction, and the saving (and therefore increased profits), which can be thus effected, amounts nearly to the whole of the fixed charges over the increased tonnage. There are certain inevitable coordinate reductions in working expenses, other than fixed charges, as the result of a larger volume of output. What these amounts will aggregate, in increased profits on the increased tonnage, depends somewhat on the proportion of the increased volume to the volume previously treated, but the total saving on the increased tonnage may be taken in minimum as equal to the fixed charges. Also the profits will be increased by the interest earnings of the extra profit taken out, as between the earlier time it would have been put into service by the secondary equipment, and the later time it would be released by the primary equipment. If this be taken at a fixed rate, say 4 per cent compound interest, it then becomes a factor of the profit per ton of ore. A minor addition also arises from the increased interest-earning on the greater profit secured by the increase of profit arising from the saving of an amount equal to fixed charges. We may consolidate all these additions to profit, as the result of expanded output (of course not including the ordinary profit on the ore), into the one phrase "increment of profits."

How important this "increment of profits" may become will be seen by taking a few examples. On a low-grade deposit, yielding a profit of $2 per ton, under California conditions of fixed charges of, say, 30c. per ton, on an increased tonnage of 15,000 tons per annum, the increment at the end of three years would amount to over $20,000. With a mine yielding a profit of $10 per ton under Western Australian conditions of a fixed charge of, say, 75c. per ton, the increment in three years on the same in-

[1] By "amortization" is meant the recovery of capital invested with accumulated interest thereon

creased tonnage would aggregate over $65,000 The rapidity with which this increment of profits accumulates is a more detailed demonstration of the advantage of the maximum output, and it is also a demonstration of the necessity for a maximum speed of development.

The volume of these savings is so large as to render the question of justification of increased capital expenditure for their realization a matter of easy approach.

(2) Reduction works, and subsidiary plants thereto, represent large sums of capital, and such plants are either worn out or become valueless through exhaustion of the mine. The hypothesis that the clothing of dead mines is valuable was long since exploded, although the public sometimes seems not to have heard of the explosion. In any event, the capital must be recovered from the mine, with compound interest, during the life of the mine. The cost of installation varies with the locality, character of ore, etc.; but we may take the example of a Californian gold mine on the one hand, where equipment to handle an output of 15,000 tons per annum would cost, say, $18,000, and, on the other hand, a West Australian gold mine, where the same volume of ore handled would involve an expenditure of $50,000, with more complex treatment and other causes involved. The Californian plant, with 4 per cent compound interest, at the end of three years, would stand in at about $20,000; and the West Australian plant at about $57,000.

In these cases, less than three years' accumulation of the increment of profits is required to amortize the entire capital involved. Given an instance of a low-grade ore and a high construction cost, the necessary time would be longer, but in a particular case which has come under my observation, of very high profits per ton of ore and moderate installation costs, the increment of profits over 18 months was sufficient to amortize the expenditure.

(3) At the time of proposed equipment the life of a mine of this class is an unknown factor. Despite this, however, as shown above, the increment of profit so overtakes amortization as to make it necessary to have but short life in sight to justify the capital expenditure.

A certain part of the life of the mine is tangibly visible in its ore-reserves. Unless a blunder was made in initial installation

(or in the remote case of a mine fully developed before equipment), then with vigorous development and continuity in depth the ore-reserves of a mine will gain on the treatment capacity. This gain will eventually reach a point where the visible life becomes equal to the period at which increment of profits overtakes amortization. So long as the reserves continue to gain upon the treatment plant, additional units should be erected until the most vigorous development is no longer able to more than keep pace with the output. Nor will such a policy entail an unusual accumulation of ore-reserves; in most cases it will be not more than a three years' supply. Thus it becomes possible to determine absolutely the volume of treatment capacity without any speculation as to continuity in depth. That it is an obligation of good management, to set up additional treatment units whenever increment of profit due to them will overtake amortization, is obvious.

It seems clear, then, that the maximum profit from any mine can only be obtained by the most rapid exhaustion of the mine, and that most rapid exhaustion is to be secured only by the most rigorous prosecution of development and the maximum equipment which can be employed. Yet in the majority of mines the caution of sound business management, owing to the unknown factor of continuity in depth, imposes limitations upon the extent to which capital should be invested in equipment, and a general rule for the determination of the size of equipment might be framed as outlined herewith:

If by vigorous development the visible life of the mine, as shown by the ore-reserves, is lengthened so as to exceed the time required for a unit of treatment capacity to earn an amount, through the increment of profits, equal to amortization of the capital invested in that unit, then the installation of another unit becomes not only justifiable, but an obligation of good management.

The Economic Limit to Accumulation of Ore-Reserves. — This subject may appear as merely a phase of the preceding, and a natural corollary to it. We have a limit beyond which the increase in ore-reserves justifies an increase in plant units; in other words, there *is* a maximum reserve which it is advantageous to have in a mine.

It has been suggested that, given a deposit of fairly regular continuity in depth, an accumulation of ore-reserves to this ex-

cessive extent means a certain amount of locked-up idle profits, and that this profit might be secured without over-equipment if the management took the risk of increasing the output before they were wholly justified by the increase in reserves, the result being that the same maximum output could be maintained without the loss. Aside from the risk, there is one matter of general policy in the conduct of a mine which affects the case; it may be expressed thus:

Every deposit of the character under discussion is sure to get poorer eventually and fail at some point in depth. On a paying mine, failure at any given level does not mean the abandonment of the mine at that point. To what depth the search for ore should be pursued through blank country is a matter of local judgment based on the character of the deposit and the conditions which determine its discontinuance. That this work should be pursued while the reduction works are in operation is a *sine qua non* of good management. Not only does it cost less while other operations are in progress, but the mine is providing the expenditure required to do it, which the owners are not likely to do afterwards. Mines are difficult to kill in proportion to their greatness; the more profitable their past career the deeper will their unprofitable exploration be carried. A mine with an ore-reserve equal to the period set out above possesses the sinews for pursuit in depth for an equal period; and that period will probably prove sufficient to exhaust reasonable hopes and to prevent the premature abandonment of possibly valuable property. As a matter of policy, then, I believe that the maximum provided as above should form also the minimum.

The economic and advisable ore-reserve, therefore, will be equal in volume to the annual output multiplied by a number of years just under that needed by the increment of profits to equalize the amortization required to construct increased treatment units.

EQUIPMENT AND ORE-RESERVES—I

(Editorial, March 24, 1904)

WE take particular pleasure in publishing an article by Mr. H. C Hoover on so important a matter as the economic ratio between the capacity of the reduction works of a mine and the tonnage of its ore-reserves. As a basis for argument Mr. Hoover has assumed the existence of a plant, and proceeds therefrom to discuss the additions to it which are warranted by an increase in the amount of ore available for treatment. There are thus two problems: first, what size of mill to start with, and then, what additions to make as the mine grows.

In most cases the plant is started with an economic unit, which in California is usually a 40-stamp mill, while at Johannesburg it is a 200-stamp mill. We do not know that this is reasoned out further than that the capacity is based roughly upon the amount of ore which can be opened up in the course of ordinary development; that is, the mill is expected to exhaust the existing stoping area about as fast as new ore-reserves are opened up, so that the original tonnage available, equivalent to a two or three years' supply, is maintained until such time as development is unsuccessful, and the mine begins to show exhaustion, then the reserves in hand are used up during a further period of exploratory work. A mill is not erected of such a size as to consume all the ore in one year, for example, because the initial supply generally represents the result of several years' development, and to start out at such a gait would shortly end in the necessity of shutting down part of the plant. In the West it is not uncommon to base the mill capacity upon the amount of ore to be extracted from one "lift," that is, the tonnage stoped between two successive levels one hundred feet apart; it being the experience that to open up one lower level per annum, while consuming the reserves of one upper level, represents a scale of working which is comfortable. However, in ordinary vein mining all such methods indicate an

unspoken recognition of the fact that each deeper level brings the mine nearer to the horizon of eventual impoverishment, while on the Rand the limit set to exploitation by the area of the claims, affords a more definitive termination to the winning of ore.

Having a certain equipment at the start of operations, what addition to it is warranted when increased ore-reserves are created in the course of successful development? That is Mr. Hoover's question, which he himself answers. It can be stated also thus: An increase in the mill is justified when the redemption of the capital involved, plus interest upon it, can be more than balanced by the saving in cost, or by the "increment of profit," upon the additional tonnage taken from new ore-reserves. The subject can be treated by differential calculus, and, from a mathematical point of view, it might well serve as a thesis for advanced students at our schools of mines. From the standpoint of financial experience and practical mining, it affords room for a discussion which is well worthy of the best consulting engineers in the profession. We commend it to their earnest consideration.

EQUIPMENT AND ORE-RESERVES—II

(Editorial, April 21, 1904)

As yet there has been but little discussion of the interesting article by Mr. H. C. Hoover on the subject of the proper ratio of mine equipment to ore-reserves. Mr. E. G. Spilsbury, in our issue of March 31, and Mr. B. B. Lawrence, in this issue, agree in their opinion that American mining rarely affords conditions warranting such a nice adjustment between the ability of the mine to produce ore and the capacity of the mill to consume it. Owing to the uncertainties of the one and the positiveness of the other, it seems, from their point of view, best to err on the safe side and erect treatment plants which are well under the probable production. A manager, of course, likes to have something up his sleeve; it is better from his standpoint to have an accumulating ore-reserve underground than to hang up ten or twenty stamps; he would rather have ore lying broken in the stopes than shut down a part of the cyanide plant for lack of an adequate supply. But, as a matter of fact, the capacity of the initial plant is usually ahead of the rate of development; and as soon as there is evidence that the two approach each other, the owners call for an increase in the reduction works, because they want to rush the output. The American idea is to secure certain and immediate profits at the expense of ultimate possible economy. While the engineers may appreciate the benefit of plans which purpose the amortization of capital, and though they may be fully awake to the economy of a proper balance between the capacities of the mine and mill, they are brought abruptly against conditions which completely upset any logical solution of the problem. The owners refuse to take a far-sighted view, and prefer a plan of operation which results in immediate profits; therefore the manager has to adjust his point of view to theirs; he is confronted by a condition, not a theory, and adopts a policy which is practical, though short-sighted, which hugs the brutalities of fact while it

disregards the attractions of system; it is the inevitable consequence of a short-lived ownership of mines

For, behind all the arguments for and against an enlarged mill-capacity or an increase in mine development, there stands, frank and unashamed, the essentially American idea, that it is a poor business to work for posterity. "What has posterity done for us?" the cynic asks. "Let us take short views of life—and of mining; why inaugurate a policy the benefit of which it requires years to work out while the expense of it burdens the present?" In this connection "posterity" means successors in any form, whether they be shareholders, who five years hence may have acquired the holdings of the present proprietary, or whether it be the engineering staff—general manager, mine superintendent and shift bosses—who, likely enough, will in the course of time, or with change of control, succeed the existing management Mines get bigger or smaller; people make as much money by selling out of them as by buying into them; there is a healthy growth or a steady decadence; in an intensely active and pushing community, such as an American metal-mining district, nothing stands still. In the coal regions it is different; fixity of ownership is more prevalent and a consistent policy has an opportunity to justify itself. But in the West, it is a fact that the control of mines passes, as a rule, in less than five years, and the manager is changed on an average about every two years, either because a better position is offered to him, or because a better man is found for the position, or for any one of the several reasons which bring about new appointments to such posts of responsibility.

Tangible profit is the aim of the American system, or the excuse for the want of any system; sometimes that means a mill with a capacity per annum equal to the total ore-reserves, sometimes it means no mill at all, but the disposal of the output to custom mills and smelters; sometimes it means no mill and no production, but merely a preparation of the mine for a sale; in each case the object in view is the making of the most money out of the property in the shortest time. The method has the faults of its virtues.

While the foregoing is believed to represent current practice in this branch of mining economics, we realize fully that there is a large number of well-organized mining proprietaries which operate mines with no view to exhausting them or to selling them or

the shares in the companies controlling them, and which therefore adopt a system in which amortization of capital and other nice adjustments are recognized factors. Taking a broad view of mining activity, the description given above will nevertheless be recognized, we believe, by those who are best informed, to be a fair statement of the case, the discussion of which presents many points of view.

This subject is of great practical importance to the business of mining, and we trust that some of our experienced engineers will use our columns as they take us into their confidence.

EQUIPMENT AND ORE-RESERVES—III

(Editorial, May 5, 1904)

THE contribution on this subject by Mr. W. R. Ingalls will be read with interest, for it is an able argument in favor of the logical treatment of the problem. Last week we emphasized that aspect of it arising from the short ownership of mines in our Western mining regions; it is a view of the subject which will inevitably become modified as mining is put on a sounder basis, but that it is the characteristic American standpoint we are compelled to confess. The Comstock period (although accompanied by manifestations of great energy, mechanical resourcefulness and the invention of ingenious machinery to meet new conditions) was more particularly remarkable for the rapid exhaustion of big bonanzas; and the wastefulness of that great exploitation affected injuriously the methods of an entire generation of mining men west of the Rocky Mountains. It represented an American type, just as the conservative, unprogressive ways of Freiberg, for example, typified European ideas of working out a mine. Both extremes are wasteful and illogical; as any serious consideration of amortization of capital and possible increment of profit will abundantly prove. In New York, no less than in London, new ideas are developing; the introduction of business acumen into the erstwhile gambling of mining tends happily to elucidate the necessity for treating mining undertakings as financial enterprises surrounded by conditions involving some of the same logical reasoning as manufacturing.

The time was, not long ago, when English investors in mines bought shares in properties the value of which was based chiefly on their past production, and if by chance they got an annual sixpenny dividend, accompanied by soothing explanations of future betterment, they went home content with their venture; and the shares would stay close to their par value of £1 until eventually, but inevitably, the company went into liquidation,

after the shareholders had not only lost their capital, but had also received a smaller rate of interest than they might have obtained elsewhere. Ore-reserves, equivalent to a year's production, were spread over five or six years' operations, the manager and staff got their salaries, the directors got their fees, and in the end the shareholders "held the baby," when those who were responsible for it had cleared out without apology. To that era succeeded the flotation of rich mines with large available reserves, their rapid depletion accompanied by a boom in the shares, the accumulation of fortunes by clever insiders, the speedy ruin of those who bought at top prices, a collapse, a moral, and finally a resuscitation of the mining company under new management. It is obvious that if the public are willing to be educated, indirectly through the professional men whom they employ, to realize the fundamental principles of finance, they will object as much to the long life of a mine which means the swallowing of profits in general expenses and salaries, as they will protest against a reckless pouring out of its wealth in a brief spell of inflated returns which is accompanied by "in and out" selling of shares among its own employees and such total lack of economy in the management as is inevitable when mere rapidity of output is the aim of all operations, without any regard for the future of the enterprise.

Both methods are seen to be destructive of mining as a respectable form of investment; the right appreciation of them will bring home the fact that the magnitude of the equipment, with its corollary, the rate of production, must bear some logical ratio to the size of the ore-reserves and its accompanying factor, the vigor of development.

MINE EQUIPMENT AND ORE-RESERVES

(March 31, 1904)

The Editor.

SIR—I have read with much interest Mr. Hoover's paper on "The Economic Ratio of Treatment Capacity to Ore-Reserves" Every member of the profession who has been long in practice knows that this is one of the most troublesome questions that he is called upon to solve, and which, leaving out the small minority of exceptionally favored mines, is seldom solved satisfactorily

Theoretically, Mr. Hoover's deductions may be perfectly correct, but in actual practice it would be very difficult to attempt to apply them to the general run of mines, as operated in this country.

In the first place, from my own experience I can safely say that the ore-treatment plant, whether milling, concentrating, smelting, or other reduction means, of over 75 per cent of all the mines I have known, is, from the initial erection, well in excess of the output of the mine, under all ordinary conditions of development. Under such conditions, however, a property is perhaps returning a fair profit in addition to an amortization fund of say 5 per cent. At this rate of extraction, and with reasonable development, we will assume that a two years' ore-reserve of the average value can be maintained. Now, supposing it were decided to follow Mr. Hoover's suggestions as to the best method of obtaining the greatest profit from this mine, it would be necessary to increase the development expenses many times what they were before. In addition to this, unless the development work were all in ore, the hoisting plant would probably be over-taxed, in getting rid of the waste material. All this would result in diminishing the immediate distribution of profits, if, indeed, it did not extinguish them altogether

Now, having by these means developed a further two or three years' reserve of ore, and probably incurred the dissatisfaction of all the stockholders, it becomes necessary to build such an addi-

tion to the treatment plant as will be requisite to take care of this increased production. Profits having been eaten up by the previous extra development, the patient stockholder is either required to subscribe additional capital for the increase of the plant, or see the value of his holdings reduced by the issue of more stock. To offset this, he is told that the increase of capacity will result in lowering the cost of production. This is, of course, a fact; but will not that saving in general expenses be overbalanced by the heavy charges which must, in justice, be made for the amortization of the cost of the increased plant, which should be coincident with the exhaustion of the two or three years' ore-reserves, which alone have justified its erection?

I think it is self-evident that the stockholder of such a property would, at the end of five years, when the assumed reserves of ore had been exhausted, be in a much better financial condition with the original reduction works only than he would be at the end of three years with the expanded capacity and forced production.

In nearly forty years' experience I have known many mine failures due to a too great development of treatment capacity, but never one due to preponderance of mine capacity over that of the reduction works.

We are all too prone to discount the possibilities of a mine's resources, and prepare our surface works to meet the requirements of these possibilities; and while, theoretically, the expansion of the treatment plant should keep pace with the mine development, it is generally in practice more profitable to the investor when the opposite maintains.

E. Gybbon Spilsbury.

MINE EQUIPMENT AND ORE-RESERVES

(April 21, 1904)

The Editor

SIR—Mr. Hoover's paper on "The Economic Ratio of Treatment Capacity to Ore-Reserves" upon which you have invited criticism, has received my careful consideration. I have also read with interest your editorial upon the subject of "Equipment and Ore-Reserves."

In my experience in precious metal mining in the United States it is the exception to find a mine which shows anything like the ore-reserves necessary to carry out any such plan as suggested by Mr. Hoover. I might venture to say that there are very few mines, unless they are for sale (or fixed up for a sale) which have any substantial ore-reserves ahead to enable one to think of "amortization" or "increment of profits." These terms, it seems to me, are all right in the manufacturing business, but I doubt very much the wisdom of using them in regard to precious metal mining. Hand-to-mouth methods are the rule, and we must unfortunately adapt ourselves, our plans, etc., to conditions as they exist.

I notice that you are obliged in a footnote to explain to your readers the meaning of "amortization." This in my case—I blush to confess it—was most necessary, as I have never had occasion to use this term in the every-day business of mining. Mr. Hoover says that "the increment of profits for 18 months was sufficient to amortize the expenditure." Why not say "offset" the expenditure? Of course I shall bring down on my head a severe criticism as to the views which I have expressed in regard to Mr. Hoover's article; but it does not seem to me clear, nor does it appeal to my common sense, as applied to precious metal mining in this country.

BENJ. B. LAWRENCE.

New York, April 8, 1904.

ANOTHER ASPECT OF MINING FINANCE

(April 28, 1904)

The Editor:

SIR—Your interesting articles recently on "Some Aspects of Mining Finance," in my judgment, fail to illustrate the latest English development of the subject. Out of the chaos of mine promoters, finance and exploration companies there has recently appeared entirely another form of mining finance and management. There are certain firms, composed of partners—not companies—who, for reasons which will become apparent later, have steadily come forward in the past ten years, and are fast controlling the great bulk of mining enterprise. These firms have risen in various ways; some at first originally merchants, and some mining engineers. They are composed of various partners, financial men, mining engineers, mine managers, in any event, all are experienced mining men, devoting their entire time to the work. The business is generally organized on managerial lines. A central exploration company is usually created among their friends, when any particular field is to be covered, a portion of whose capital they may or may not own. The "firm" manages this company, in return for a portion of the profits. This exploration company searches for mines under guidance of the firm, and finding them, proceeds to develop, equip, and create them into subsidiary companies, which are in turn managed or controlled by the firm, sometimes for a portion of their profits, sometimes for direct fees. Whatever the details of internal arrangement may be, from the standpoint of the investor and outside engineer, the result is the same, and there are three or four features of this development that are worthy of note.

1. The position of a board of directors sinks into the background, for the clients of the firm find the capital for its enterprises, and these clients look on the firm as responsible; *ergo* the firm usually fills the board with its own partners, or men of its "group," who will guard their responsibilities properly from a

directorial standpoint. Scandals from mismanagement by directors have been of rarest occurrence in these groups, both because of the domination of the firm, and from the *personnel* forming the boards.

2 The administrations of the mines are of very superior order. These firms usually confine their operations to specific regions, and the administrations of several mines are usually grouped together under a staff of specialists, such as no single mine could afford to employ. Supplies are bought in very large bulk, direct from manufacturers, and London expenses, by combined offices, are kept at a very low figure. The quality of men employed as managers and engineers in these groups is usually of a superior order, because, with a great staff, invaluable opportunity for comparative results arises, and the best man is rapidly brought forward. "Working costs well balanced by extraction and working results" is the watchword of administration.

3. The position of engineers and managers in such groups is much better than that of those employed in single companies, which are usually dominated by boards of titled nonentities, or worse.

As the manager or engineer with these firms is not dependent upon the success of any one mine for his future—for "good mines do not make good managers"—under this form of administration, the opportunities of promotion are much wider, and constant employment more certain, for the field is not limited, as said, to one mine. Other larger mines, staff positions, and ultimately partnership, are steps directly open to a capable man.

4. Firms of this character have a name to maintain, for on their good name does their ability depend to secure the vast sums of money which they employ, and they are never guilty of undertaking "wrong" ventures. At times even, when the failure of mines in depth precipitates a loss, they have supplied a new mine at their own cost—not for charity, but to keep alive the necessary confidence in their ability and integrity.

The irresponsible promoter, who puts up a dummy board of pompous dignitaries until his shares are disposed of, is having great difficulty to get the public ear, and must disappear. These same pompous dignitaries are a sore trial to the honest manager, who slaves at the mine over working costs, and periodically meets

their enquiries why he does not increase profits by raising the amount of gold per ton, instead of trying to reduce costs.

A feature of this form of organization which is making itself felt is the continuity of the firm. Its senior partners retire and younger men are brought from administrative positions in the field, and the firm goes on. Transitory transactions for immediate profit, at the risk of good name, are not indulged in, for the name must be sustained. The investing public is fast recognizing this, and the universal preliminary among investors is a statement regarding a mine, that is, that it is a K. G. & B. mine, and not that Admiral Sir Damfunny is chairman.

There is a marked tendency among these firms to territorialize, that is, to confine themselves to specific regions. In many instances they are interested in concerns which they do not control. There are in London seven or eight such firms of prominence, South Africa furnishing the field for most. The leading firms in the four principal mining regions in which Englishmen are mostly concerned are mentioned below, with an approximation of the nominal capital and market value of the enterprises they control or manage. The members of these firms are often, as said, interested in other concerns; only those identified with the firms are included:

	Region of principal activity	Nominal capital	Market value.
Wernher, Beit & Co	South Africa.	$85,500,000	$342,000,000
Bewick, Moreing & Co	Australia.	42,100,000	70,550,000
John Taylor & Sons . .	India, etc	30,500,000	65,500,000
Tarbut, Son & Jansen.	West Africa and Rhodesia.	55,500,000	25,100,000

The market price for these enterprises, as compared with their nominal capital, gives food for thought.

There are in London, as set out in your articles, several exploration and finance companies which are not controlled by such firms. At one time they predominated in the mining finance of London. Some have been managed with consideration for the public, and many not so In all cases, practically, they are flotation companies pure and simple. When a mine is floated, so long as they maintain in it a considerable interest, they continue

to look after the mine and guide its management, but as soon as the mine is in the hands of the public, they promptly forget it for other matters, and the administration goes to the dogs. Hence the investor has begun to consider somewhat, not only the character of investments offered him, but also whether he will need to "carry the baby" all alone or not.

In general, in the finance-company arrangement, set out so much in detail in your columns, the ultimate tendency is even worse than with the individual promoter, for the latter has at least some moral responsibility, and a corporation has none The general result is that the "firm" is rapidly becoming the main source of mine finance—and so much the better for the industry There is no finance company in London the ventures of which in the aggregate stand on the market at an amount equal to their nominal capital—itself a useful indication of previous career.

OBSERVER.

London, April 13, 1904.

THE ECONOMIC RATIO OF TREATMENT CAPACITY TO ORE-RESERVES

(May 5, 1904)

The Editor:

SIR—Mr. Hoover is apparently the first to express in the form of a scientific generalization a principle that has been well recognized by engineers as sound in theory; also as true and praiseworthy in practice, subject to limitations, which it seems to me Mr. Hoover clearly referred to, and thus disarmed the criticisms of Mr Spilsbury and Mr. Lawrence. The principle is briefly: The more quickly the values of a mine can be realized, the larger will be the net profit. A practical limitation of this principle is the uncertainty as to the ultimate resources of the mine, involving hazard in the provision of ore-treatment capacity. Mr. Hoover's purpose is simply to formulate general rules indicating when there is no hazard, but, on the contrary, the probability of increased profit in the investment in additional plant. There is, however, another limitation in many cases, which Mr. Hoover has not considered, because I conceive he has gold mines especially in mind: that is, the limitation of the markets.

In opposition to Messrs. Spilsbury and Lawrence, I fail to see, Mr. Editor, wherein American conditions differ from those of other countries in so far as the ore deposits are concerned. All have ore deposits of various kinds; some small, pockety and uncertain; others large, regular and persistent. Our American conditions differ perhaps from those of some other countries in affording better public markets for the ores, relieving the miner from providing any treatment capacity, permitting him to sell as much ore as he can extract, and enabling the intense operation of his property, doing in fact the very thing that Mr. Hoover advises; hence the short life of many of our mines. There are, however, many mines in America which require individual plants of one kind or another. That some of these, nay even many, have been provided with an unprofitable excess of treatment

capacity (of which we all know a multitude of instances, and doubtless there are proportionately as many in Australia and elsewhere) does not disprove the correctness of the principle that Mr. Hoover formulates How can it be said that this is a principle that is true enough in theory, but of little practical application in a country which possesses copper mines showing the ore-reserves of Lake Superior, Butte, Bingham, and the various districts of Arizona, lead mines showing the ore-reserves of the Cœur d'Alene, Bonne Terre, Flat River and Park City; zinc mines like those at Stirling Hill and Franklin Furnace; and gold mines like the Homestake and the group on Douglas Island, Alaska? I have seen mines which have had an excess of treatment capacity; I have also seen those which have had a deficiency.

Take for example a very wet mine, producing 150,000 tons of ore per annum, the cost of pumping water being $30,000 per annum. The estimated life of the mine is in excess of 10 years. The extra cost of plant to permit the production of 300,000 tons per annum would be $100,000. The saving in cost of lifting water per ton of ore would alone re-imburse the cost of addition at plant in about four years, at compound interest, not to speak of other savings that would ensue. This case is entirely analogous to those which Mr. Hoover cites. Another method of illustrating the idea is afforded in the experience in numerous districts in the United States where large bodies of low-grade ore are mined; a mine worked on the basis of 1,000 tons per day may be profitable; on the basis of 100 tons per day not so. Is not this principle entirely in accordance with the American idea that it is poor business to mine for posterity?

I do not consider that this discussion is supposed to cover the policy of the holder of a short lease, whose interest may be distinctly to gut a mine; or that of a fortunate adventurer who may find it most profitable to pick the eyes out of his mine; but rather to the policy of the operator, who has probably purchased the mine on tonnage, assays and prospects, and has paid for the low as well as the high-grade ore. When money is invested in the purchase of a mine it has got to earn a dividend commensurate with the risk, and it also must be refunded, else there is no profit. The more quickly the principal can be refunded, the greater will be the profit, because $10.000,000 in value that can be realized in 10 years is worth more as a purchase than $10,000,000 that can

only be realized in 40 years. Amortization of the principal is therefore a very important consideration Amortization, which is a term more used by British and French engineers than American, is a very good word, there is no other single word which precisely conveys the same meaning

Let us take the case of a mine sold for $500,000, which was supposed to contain at least 3,000,000 tons of ore The mining and milling plant required to produce 1,000 tons of ore per day (300,000 tons per annum) would have cost $300,000. The profit per annum would have been $213,750 (71.25c. per ton of ore), which would have been nearly 27 per cent on the investment. Instead of this, the mine was equipped to mill only one-third as much ore, though it was already developed to twice as much capacity, the total cost of development and equipment being about $160,000. The profit per annum was about $56,250 (56.25c. per ton), which was only 10 per cent on the investment, or only sufficient to re-imburse the latter in 10 years, without interest. By selecting a better grade of ore than the average, which the mine was opened sufficiently to permit, there was a gross profit of about $100,000 per annum, or a little less than 18 per cent, but this policy would have led to rapid exhaustion of the mine, leaving great bodies of ore too low in grade to be mined, with the prospect of doing no more than returning the money invested, without interest. Operation of the mine on the basis of 1,000 tons per day promised in 10 years a profit of $2,137,500, which would have refunded the original investment at the rate of 10 per cent, with interest at 6 per cent, and would have left a surplus of $1,073,500, or an average of nearly 13.5 per cent per annum as profit on the investment. Can there be any doubt that this mine, if originally opened in a small showing of rich ore, and provided with small equipment, should, when development indicated the true condition, have promptly been provided with increased facilities?

Another case in the same line occurs in the handling of deposits of rich ore in connection with large deposits of poor ore. A certain mine was producing 100 tons per day of smelting ore at a cost of $2 per ton, of which 30c. per ton was for pumping water and general expense—administration, supervision, assaying, surveying, taxes, insurance, etc.; and 100 tons per day of low-grade ore, which was concentrated in a mill—cost about $25,000

—to 10 tons of product netting about 37·5c per ton of crude ore, the latter being charged only with its direct expenses. The high-grade and low-grade ores were known to exist in the ratio of 1:3, but were being extracted in the ratio of only 1:1. Obviously, the result of this policy was to leave 50 per cent of the ore, all low grade, in the mine in a form wherein it could not be extracted at any profit at all, a contingency that was pointed out by the engineers.

These examples are from practice, but as they refer to the private business of close corporations, the details have not been entered into and the figures have been generalized, the object being simply to illustrate the principle which Mr. Hoover argues; that when the increment of profit exceeds the cost of additional plant, extension of the latter should be made.

I have previously remarked the limitation that may be fixed by market conditions. For example, if the entire market for a commodity be supplied by a single ore deposit, no matter how extensive the deposit may be known to be, its exploitation is limited by the capacity of the market. This is not at all a suppositituous example. I fancy this consideration enters into the calculation of the managers of some of our great mines, and it is weighty, else why the agreements to limit production that in one way or another, at one time or another, have been made in almost all of the great metal industries, gold and silver excepted? The Calumet & Hecla mines are supposed to have a further life of 25 years at their present rate of production; the other great copper mines also have great ore-reserves; but suppose the dozen large producers, who make approximately 50 per cent of the world's output, should, at one and the same time, enter upon the policy of intense production, the effect upon the price of copper would immediately be manifest—and the diminution in value would probably wipe out forthwith the entire increment of profit. It appears, therefore, that while the theory of intense production is correct, and the results of practice may correspond, subject to limitations, it is rather fortunate that the practice is not generally followed, again excluding gold mining.

Before concluding this rather lengthy contribution, reference may well be made to a new condition in ore treatment, which is developing in the United States. Many years ago it was a common practice to put reduction works at the mines. Later, public

works were established at central points to buy and treat the ores from many mines Now it is again becoming common for the great mines to have their own reduction works, but they are being put at central points, and are intended to buy and treat the ores from other mines. The effect of this is to accomplish all that Mr. Hoover argues for, and without so much risk to the individual mine. In fact, the ore-reduction business may go on, and the works still have value as a manufacturing plant, after the mine for which they were primarily erected has been entirely exhausted.

W. R. INGALLS.

Boston, Mass, April 25, 1904.

MINING IN RHODESIA

(March 24, 1904)

The Editor.

SIR—In your issue of March 10 there appears a letter purporting to be a "friendly criticism" by Mr. Wallace Broad upon an article contributed by me entitled "Gold Mining in Rhodesia" It is unfortunate that the general tone of Mr. Broad's contribution is not one which conduces toward friendly discussion.

In the main, the criticisms are so vaguely put as scarcely to warrant comment. There are, however, some views rather forcibly expressed by Mr. Broad, which appear to me to be narrow enough to invite brief reply.

Mr. Broad seems to be confused with regard to the application of many of the remarks contained in my article, in that he associates them wholly with a property upon which he did some prospecting work. As a matter of fact, I utilized the impressions and figures obtained from four different mining companies with which I have been professionally connected for some years. Taking his paragraphs seriatim:

1. The Penhalongha mine, situated in Mashonaland, is the only mine in southern Rhodesia which it has been found "advantageous" to open with adits or cross-cuts. Unfortunately, to date, this class of work has not been wholly confined to this property. There are many mines in Rhodesia the early development of which was attempted through adits; indeed, at both the Bonsor and Tebekwe mines, a good deal of this class of work was started, but it was found later that vertical or inclined shafts would be necessary (by reason of the limited amount of ore obtainable above the lowest adit level); so that under adverse conditions and at great expense, in which temporary and partial suspension of milling played an important part, these properties were permanently opened through shafts.

There are many Rhodesian prospects which contain adits, but I know of no instance where this work has been of more than

temporary importance Indeed, I know of one property in particular where no less than 2,700 ft. of work was carried out on ore which outcropped less than 60 ft. above the level of the adit.

2. The elevation of the plateau upon which Bulawayo is situated, is as stated, namely, about 4,450 ft. above sea-level, but the individual hills and kopjes rarely reach an elevation of more than 300 ft. above the undulating plains in their immediate proximity.

One of the sights of southern Rhodesia, which has evidently escaped Mr. Broad, is the World's View, a spot in the center of one of the large "granite belts," and named by that empire builder, Cecil John Rhodes. In the very midst of this extensive area, which has been described as "an undulating plain, embracing a perfect sea of conical-shaped kopjes," lies all that remains of this great man. Similar natural monuments in a modified form are found in all the granitic belts of Rhodesia. In these belts numerous quartz deposits occur, chiefly segregations, but, with the possible exception of one or two lodes, no economic value can be attached to these occurrences.

7. As compared to the numerous alluvial districts in which the writer has mined on the Pacific slope of the United States, the deposits of southern Rhodesia are extremely limited, not alone in vertical depth, but in superficial area. Having examined a large number of these occurrences in Rhodesia, I have rarely found a depth, including "top dirt," to exceed 20 ft. Although some of the deposits contain fair gold-values, very little attention has been given to this branch of mining, for the reasons already stated.

One would hardly expect the same degree of erosion to obtain in a tropical climate as in a climate where extreme cold obtains.

9. I was not aware that any definite statement had been made by any of the archæologists who have investigated the ancient ruins of Rhodesia, touching the peoples who actually were responsible for the numerous old workings existing in the country. From the works I have read, I gathered that considerable doubt existed upon this subject. Mr. R. N. Hall, who has made an exhaustive study of the subject and who has carried out some very important work lately, at the Zimbabwe ruins, in discussing the material which is to be embodied in his new

work shortly to be published, informed me, only last November, that he had been able quite recently to upset many of the older theories, and, in fact, is making many alterations in his own original work.

11. If, in assuming a payable limit to the grade of any given ore, and graphically segregating the payable from the non-payable ore, as well as applying the same idea to the other factor, "width of vein," one is not comprehensively defining the lateral extent of individual shoots which it is intended to stope, perhaps Mr. Broad will favor us with the more important considerations. As a matter of fact, to the professional man, the graphic expression of values and widths has not much significance. It has its importance, however, in that it provides a ready means of enlightening those who are unable to comprehend the points at issue by reason of the maze of figures and methods necessarily employed in such work.

12. Mr. Broad has gone entirely astray on the subject of development work. In the first place, it is not customary to charge the cost of shafts to "development work." This disbursement is charged direct to "capital" account. All shafts are treated as assets, and the moneys expended thereon are redeemed through depreciation account, as it is presumed that the shafts will be of use just as long as any of the surface equipment.

It is necessary to establish a basis in dealing with the development redemption account, that is, in redeeming the moneys expended in developing the ore which it is expected to mill, and as all other distributions are made on the basis of the tonnage milled, it is usual to treat development account in the same manner; the cross-section of the driving or winzing has absolutely nothing to do with the matter, nor is the small amount of clean payable ore, taken from this work, of significance; much less the total cubical contents in waste rock and ore, which Mr. Broad has, *without having had any vein widths*, taken so much trouble to compute at 4,500 tons. As a matter of fact, in the case cited it was found advantageous to extend the development work into the foot-wall of the vein. The calculation was quite correctly given by me, and was arrived at by dividing the total cost of development for a certain period by the number of tons milled during the same period. The cost per foot, for the work, was, as explained, above the average, because a comparatively small

footage was obtained during that particular period, but, as stated, individual months could have been chosen which would have shown a great improvement. The object, however, was to show the distribution of the moneys expended upon the work rather than to present a lot of flattering figures. Development work, that is, drifts, when extended with machine drills, in hard rock and on a comprehensive scale, seldom costs less than $20 per foot in Rhodesia. This of course includes all expenses not only at the mine, but in London and at the local offices, and engineers' charges. It is quite clear that an excessively small footage, where a full staff is being employed and other constants are evident, reflects unfavorably in the cost per foot. Perhaps Mr Broad had in mind the bare contract price, which in Rhodesia ranges from $6 per foot in oxidized ground to $15 per foot in hard rock. The facilities offered in individual cases are also an important factor

13 The idea expressed by Mr Broad that it would be advisable to exclude the air-compressor from the equipment of a mine, and in consequence (by reason of the irregular supply of native labor) operate the mill irregularly, as has been the experience of more than one mine, cannot be taken seriously There is not one mine in the whole of Rhodesia which has been able to run continuously on ore furnished by hand labor. It is not usual to charge any part of the machinery and plant to development account.

14. In referring to the weight of stamps I had no particular plant in view. I have myself erected three mills in Rhodesia, using different weights, namely, 1,050 lb., 1,150 lb., 1,258 lb.; while as far back as 1898 I erected a mill in the Transvaal of 1,385 lb. stamps I subjoin the weights of the individual parts of the heaviest stamps yet made: Stem, 604 lb.; head, 437 lb.; shoe, 289 lb.; tappet, 135 lb.; total, 1,465 lb. The die weighed 165 lb

The evolution of the mining industry, while probably not so marked in Rhodesia during the past three or four years as in other countries, has brought about great changes in ideas, impressions and methods.

I hope that Mr. Broad, who, as indicated by his remarks, is a geologist of high standing, will favor the readers of the JOURNAL with his impressions of the geology of those parts of Rhodesia in

which he has spent so many years, and I am sure that such an article from him would prove of great interest to professional men.

Personally, I can only concede a difference of opinion upon those subjects which in my original paper were too generally stated, or in Mr. Broad's criticism too vaguely, to afford ground for either criticism or reply.

F. C. Roberts.

SECRET RESERVES

(Editorial, May 12, 1904)

THE article on this subject, appearing in this issue, by a writer so well known in Australia as Mr. F. H. Bathurst is sure to be read with interest. Apart from its local interest, the question discussed involves many of the nice points of company management and the responsibility which is inseparable from such management. When secrecy of any sort becomes a lever opening the way for successful share speculations on the part of those in a position of trust it is bad—unqualifiedly bad—because it means not only that investors are left in ignorance of essential facts, but it involves a positive danger to the *morale* of the staff in control of operations at the mine. A directorate which practices deception toward its shareholders must expect like treatment from its manager, and he in turn must not be surprised if members of his staff pursue similar tactics. "Don't monkey with a buzz-saw." To play with a code of honorable conduct is to undermine the very basis of business, and more particularly is it essential that above-board procedure should be the constant aim of those who wish to establish confidences in the speculative industry of mining.

SECRET RESERVES

By F. H. Bathurst

(May 12, 1904)

The question of the hour in Victoria, Australia, is the right of a mine manager to keep a secret reserve of gold for the purpose of averaging the yield. Attention has been directed to the subject through the discovery by one of the directors of a deep-lead alluvial mine, that the manager kept a reserve which he used for averaging purposes. The auditors, on seeing the fact announced in the Melbourne *Argus* that such a reserve existed, called on the mine manager to produce his "gold-books." The manager thereupon forwarded to them two books. No. 1 showed the gold sent by him to the bank, which corresponded with the yields as reported to the directors and the shareholders week by week; No. 2 varied from No. 1, inasmuch as this book purported to show the whole of the gold taken from the sluice-boxes day by day, and therefore it accounted for the reserve also. This reserve the manager had made up by taking gold from the daily yields when high, and storing it in his safe. It went there without the knowledge of the board, who also were not made acquainted with any withdrawals from it. The only check was, as is the case with all Victorian deep-lead mines, the sluice-man. This is the man who cleans up the sluice, and he, with the manager, weighs the gold and initials the entry of the amount in the manager's gold-book, but he does not report to the directors. The sluice-man is appointed by the directors, and therefore he is supposed to be independent of the manager. It may be added that the occasion of the auditors calling upon the mine manager for his gold-book was that the gold in reserve was not shown in the half-yearly accounts, just as it had never been shown in the weekly yields.

By the Victorian Companies' Act, directors have to publish a full statement of assets and liabilities each half-year, and in

addition the shareholders and the creditors have the right to demand (and must be supplied with, on payment of a small fee) three months' accounts of a mining company. It is easy to see that the first of these obligations—that of presenting a true statement of assets and liabilities—cannot be fulfilled if a vital portion of the assets is kept secret at the mine. In the same way it is evident that if a shareholder, in the exercise of his statutory right, demanded a complete statement of accounts, he would not get it if the directors and legal manager did not include this gold reserve. The object of the legislature in allowing this privilege to creditors and shareholders was to prevent secrecy, so that the mining investor might be on the same footing as the director or any other officials of the company. Parliament held to the opinion that it was necessary for the well-being of the industry that its affairs should be open and above board as far as was possible, and very few directors have had the temerity to offer opposition to its determination in that respect.

Now it is the practice of certain directors, after they have appointed the manager, to make no inquiry whether he has a gold reserve. "We have confidence in our mine manager and we trust him to work the mine to the best advantage," they say. "If he thinks it is desirable to keep a gold reserve to equalize yields, let him do so. We do not want to know, and if we do not know we do not tell a lie when we say to shareholders that we are not aware if a reserve is kept." It is clear that this view involves a shirking of responsibility. In Australia, whatever he may be elsewhere, the director is a trustee. The whole spirit of legislation is that he must fulfill his trust or be responsible for his dereliction of duty. Indeed, in one case it was decided that a director was compelled to make up the loss in value of shares, where he had told a shareholder who had asked his advice on the subject to hold on to his scrip. Therefore, as directors are entrusted with the control of a mine, they have no right to let their mine manager regulate the yield unless they are fully cognizant of the fact. In this connection it must be explained that the practice in Victoria is to publish yields weekly, and the market ebbs and flows as the returns vary. Hence an additional reason is afforded certain directors for not inquiring about the gold reserve, because they do not wish to be open to the charge of having secret information that would advantage them in stock

and share dealing as against the ordinary shareholder It will be seen that in this question of the gold reserve two factors operate with mining directors, first, that of trust reposed in the mine manager, and, second, that of keeping the market steady by presenting average yields.

When a short time ago Mr. Herbert J. Daly, writing in London on the subject of the gutting of the bonanza ore in the Lake View Consols, justified the action of the management in that matter, he came in for criticism in Australia. The argument used in antagonism to his was that the rushing out of rich ore should not be done, unless the mine is well developed ahead, and the company is financially so strong that it can see its way to mine in that fashion so as to give shareholders a return in the quickest possible time. Concurrently also, it is claimed that notification ought to be made to the shareholders that they must not expect their yield to keep up at a bonanza rate. Now, if the opposite policy of keeping a bank in the mine is pursued, then there will be just the same scope for manipulating yields by averaging them that there is when a manager keeps a secret reserve at the surface. Yet, in that case, the directors can be kept in ignorance unless constant sampling is done and assay-plans are regularly furnished to them to show how the stopes are advancing and how the rich ore is being encroached upon or left alone. But the law would not, as it stands, reach a mine manager who did this, and it could not touch directors who might not know anything of the true position of affairs. Of course, in Victorian quartz mines, where it would be almost fatal to a company from a share-market point of view to refuse to allow a weekly or fortnightly inspection of the property to shareholders or their experts, it would not be possible long to conceal any depletion of the rich reserves, or for the matter of that, any hoarding up of them. In West Australia, however, there are mines which are not open to inspection, and where the directors put themselves absolutely in the hands of the mine managers. In such cases it is evident that, if the frankness commanded by the law in Victoria in respect to reports and accounts is not practiced, great fraud is possible. Yields can, if a manager is dishonest, be manipulated so that if shares are wanted to be bought, returns can be made low, and kept low until scrip is bought in small lots, when the return can be gradually increased; the result being a sharp ad-

vance in market values. Then, if a bank is in existence, but the average ore is losing its richness, shares can be sold short and yields maintained until the crash is wanted. Thus it is a case of "Heads I win, tails you lose."

The same position exists exactly with alluvial mines, where a secret reserve is kept. The company is in the hands of the men who know of it. An opening for fraud exists, and it is undoubted that more than one mine manager has succumbed to the temptation put in his way to co-operate on the Stock Exchange with brokers who knew how to turn to account the secret information furnished them. Thus it will be seen that wherever reserves of any kind exist at mines the personal equation must rule, first with the mine manager; and, if he is honest, next with the directors to whom he reports the true position of affairs. The feeling in Victoria today is that there ought to be no personal equation. What investors want is that they shall know the worst or the best of mining and at once. If the ground is rich, it ought to be fairly mined and the fact reported that the yield is high because of the exceptional quality of the ore or the gravel. Or if the ground becomes poor, they do not want the manager to have his eye on the share list to try to keep quotations at a fictitious price by averaging yields at a figure which the condition of the mine does not justify. They want the directors to establish cash reserves (which will appear in the balance sheet) when times are good, and to equalize dividends from that reserve, or to use it to keep the mine going. And above all, they ask that the truth shall be told at all times in respect to the position of the mine and as to the actual returns obtained. There can be no doubt as to the trend of public sentiment in this matter, for it has been gravely proposed by the Chamber of Mines of Victoria that mine managers shall be compelled to accompany all their reports with a declaration that the contents are true. Indeed it is likely that the outcome of the recent discussion on secret reserves will be that, in the Amending Companies Bill, an attempt will be made to place a provision to that effect on the statute book. Then, if managers do not tell the truth, they will be liable to a criminal prosecution for perjury, and directors who hold back facts which might influence the course of the share market will run the risk of becoming subject to action for breach of trust.

THE VALUATION OF GOLD MINES

BY H. C. HOOVER

(May 19, 1904)

As before, this discussion is limited to that class of gold mines the continuity of which in depth is uncertain.

If a broad survey be made of the method of valuation of mines in different countries, by different peoples or by different individuals, there will be seen to be the widest divergence in the point of view. The pendulum of valuation swings between a minimum (as represented in the demands of the American engineer for a purchase price to exceed but little, if any, the actual exposed profit in sight) and an extreme maximum allowed by some representatives of the English mining investor, who find the value by capitalizing the possible dividends at a somewhat higher rate of interest than Government bonds.

The whole of this wide variation in theory and practice results from a different attitude toward that portion of the value of a mine which must be assessed to extension in depth. The one extreme allows but a few feet, while the other practically ignores the essential characteristic of mining investments—the necessity of recovering capital coincidently with an interest which compensates for the risks taken.

Were we to stick strictly to the minimum figure, but little business would take place, and but few funds would be available for expansion of the industry. There is an inherent speculation in mining, and it is this speculation which attracts; without speculation for large returns but little gold mining would be done. I think it is certainly true that mines, on the average, yield a much greater profit than the minimum stated. On the other hand, it is obvious that the maximum value, which one finds only too often assessed on stock markets by a process of multiplication of dividends, is simply gambling.

Various proposals have been made to meet this divergence of view, usually they are attempts to give a rule to the speculator or investor by which he may on the average measure his mine. Every mine is so much a problem in itself that all generalization is difficult, but any sound method which calls the attention of the investor to the real basic facts of valuation and tends to keep him on the right track, is useful.

The favorite method of blending the extremes has been to add a proportion to the profit in sight. In a recent issue of this JOURNAL it is advocated that in general a mine is worth 50 per cent more than the net profit in sight, or, in other words, the extension in depth is, on the average, worth this amount.

My friend, Mr. J. H. Curle, working on somewhat the same basis, in outlining a theory of sound investment in mining shares, says in effect.[1]

1st. The development in the bottom must be good;

2nd. The mine must pay 10 per cent per annum;

3rd. There must be 60 per cent of the price of the shares in sight.

In other words, with favorable geologic conditions, Mr. Curle estimates in general that extension in depth is worth 40 per cent of the whole value, or 66 per cent of the profit in sight.

I take it that these schemes of valuation refer only to the safety of the original capital, and do not include interest thereon, it being considered that the profit of the transaction shall arise from the possibilities beyond recovery of capital. I am not disputing the possibility of thus covering the necessary profit, but there seems something wanting where there is no expressed basis for calculating the time, etc., to gain a certain interest as well as recovery of capital.

Theoretically, at least, any scheme of valuation of extension in depth, based upon ratio of ore-reserves or profit in sight, is wholly wrong. The quantity of ore in reserve is a matter of management not necessarily dependent on the size of the mine. A mine may have a reserve so large as to imply an extension in depth beyond all reason, or, on the other hand, a mine may be extremely valuable, with no profit in sight at all. No mine starts out with an ore-reserve, and upon this basis of mine valuation the whole of prospecting ventures would be eliminated from

[1] *The Economist* (London), Sept. 5, 1903.

legitimate mining. This basis of valuation also fails to take into account the great variability in geological character between different mines and different districts in relation to probabilities of extension in depth. Moreover, if I am right in the "economic limit" of ore-reserves, as stated in a previous article, to be in the most cases from two to three years' output, then, owing to the limit reserves thus permissible, if we estimate the value at, say, 50 per cent more than such reserve, the majority of mines would yield, on above footings, from 20 per cent to 40 per cent per annum.

Inasmuch as the value of the mine is dependent (outside of the reserve profit) upon the distance that the deposit will extend in depth (or, in rare cases, laterally) beyond the region of vision, the most logical basis for estimation would be a computation of how far such extension is necessary to justify a given value, or to what depth the particular deposit may be risked to so extend; in other words, the depth of extension should be considered instead of a proportion of the profit in sight. By such a method not only would broad generalizations be avoided, but a sort of geological basis would be found. The general character and experience of the district for continuity; the special conditions of each particular deposit as to size of orebodies; the known factors, such as bore-holes, the development on adjoining mines, and the possibilities outside of immediate orebodies, etc., would all come into play in the probabilities assessed. These factors are glossed over on any system of proportional values.

An example of the working of these methods of estimation may be taken, for instance, by grouping the leading mines in West Australia. A group of 15 mines in that state is at this date valued on the London market at £14,500,000. They have profit in sight of £10,500,000. Upon a basis of adding 66 per cent to the profit in sight, these mines are about correctly valued. To recover the capital sum represented above, they will have to extend something like 250 ft. below the present bottoms; and to repay capital, and, say, 6 per cent interest during the whole period, they must extend about 480 ft. below their present bottoms. This depth is not an unreasonable risk, taking all matters into consideration. On *average* over the whole group, the two bases of valuation agree fairly well, but, taking "A" mine, for instance, with an ore-pipe 30 by 90 ft., an extension of 480 ft. is very problematical indeed, and even more so in the case of the

"B" mine, composed of lenticules of ore by no means certain, even laterally; yet in "C" mine, with two parallel ore-shoots, each 1,000 ft long and 12 ft. wide, with the adjoining mine proved already 600 ft deeper, even a longer life could be granted.

Taking a leading mine in the Kolar district in India, valued by the market at £3,600,000, in which profit in sight is roughly £920,000, the proportional value would assess it to be worth about £1,450,000. This sum of £1,450,000 would not only be recovered, but also with interest, by an extension of 200 ft. further in depth. With a continuous run of ore 3,500 ft. long, and the general geological conditions favorable, there would seem to be warrant for confidence to considerably greater depth than such a valuation would grant.

In the detailed judgment as to the probability of extension in depth, as stated above, other conditions being equal, the size of the orebody becomes the greatest factor An orebody 1,000 ft. long is much more likely to extend than one 10 ft. long. That such extension is absolutely proportional, I should, of course, not contend. An old Cornish saying was that an orebody would extend in depth a distance equal to its length. This, although it shows an appreciation of the matter from experience, does not meet the case in ore-shoots, whose general character implies greater depth than length, nor does it meet the case for partially exhausted mines.

In depth, deposits seldom terminate abruptly. The lenticularity of ore-shoots is generally recognized, and that ore-shoots usually, in their terminals, display lenticular character is, I think, generally accepted.

If this were established as an average—a worthy problem for mining geologists—it would be possible to state roughly that the minimum extension of an orebody or ore-shoot in depth would be a factor of a radius not less than one-half its length. By length is not necessarily meant horizontal length, but a section perpendicular to the downward axis. By study of 72 mines with whose orebodies I have been able to familiarize myself, I find this rule of minimum to apply in all cases but two, by taking a number of points from top to bottom of the workings. Subject to wider expression of experience, I believe that an amount of ore thus represented can be about as safely assumed as can the continuity of value through ore-reserves blocked out. I do not pro-

pose this as a method of determination, either of maximum or minimum value, but as a yard-stick possibly useful in forming a judgment. For instance in the "C" mine, cited above, having an orebody 1,000 ft. long, by such a calculation, if we assume that the orebody is about to die out, and that the bottom workings represent a cross-section of the lens, the minimum depth would be 500 ft., or an average of the whole section of the orebody about 275 ft This distance (when compared with the necessity of orebody to extend only 200 ft. to return the present market price, and only 480 ft. to return the price and interest) would indicate that the present price is fairly sound.

In general, the proposal is that this class of mine should be valued at, (a) the profit in sight; (b) a further amount based upon the extension in depth of the orebody (in volume and value as disclosed at its lowest section) for a distance based upon the probabilities in each particular mine, instead of the rough and ready method of a proportion of profit in sight.

TREATMENT CAPACITY AND ORE-RESERVES

(May 26, 1904)

The Editor

SIR—I confess to a good deal of disappointment at the meager discussion that Mr H. C. Hoover's article on this subject has elicited. To my mind, it is, from its form of treatment, the most important on the generalities of mining engineering that we have seen for some time past.

It cannot be doubted that the clear understanding of any problem in the abstract assists materially in the mastery of each example in the concrete, and, though such abstract understanding may not be the *sine qua non* of grasping the concrete, those with the clearest understanding of the abstract usually err the least in the concrete.

Notwithstanding the examples cited, Mr. Hoover's paper is one of generalities, and his broad generalizations, which crystallize into words, and perhaps in a somewhat novel form, the practice of more than one engineer, can be handled with safety only under expert advice, being in this respect decidedly dangerous in lay hands.

As an instance, the temptation is almost irresistible for the superintendent, when his costs are cut down by the addition of a secondary plant, to lower the grade of his ore as well, by the inclusion of rock that would have been, but for the secondary plant, below treatment grade. This, however, upsets all the calculations upon which the secondary plant was authorized. To be sure, the condition of the mine may actually justify it, but unless that were recognized as among the factors of the problem, and allowed for when additions were made, the property, with the increased output and with the increased capital outlay, due to the secondary plant, to pay interest upon, will actually be giving a less return per centum.

While the exact form of statement made by Mr. Hoover of the fundamentals of the problem is most striking, I am far from

sure that the simple comparative method of statement of the case of the primary plant for a number of years, as against the primary plus the secondary for the same number of tons and years, is not simpler and less liable to error in calculation; at all events, the latter is the form in which the problem suggests itself most naturally, and on these lines the following table of coefficients has been prepared. It is assumed that current profits are transferred into interest-bearing deposits quarterly, and that the interest rate is 1 per cent per quarter. This would be quite compatible with common business arrangements. For any case of primary, or primary and secondary, plant let T be the quarterly tonnage and P the profit; P T, then, is the quarterly profit.

At the end of the first quarter the profits will be P T; at the end of the second quarter, P T plus 0.01 P T or 1.01 P T; and the total profit for the two quarters, 2.01 P T. At the end of the third quarter the total profit will be 3.0301 P T. In a word, the case is that of the amount of an annuity of 1 in *n* years, and by the formula for this (Kent, p. 15) the coefficients can be worked out. For the assumed case and for six years they are given below:

COEFFICIENTS OF P T

	Gain.	
	Quarterly	Total
3 Months	1	1.
6 "	1 01	2 01
9 "	1 0201	3 0301
1 *Year*	1 0303	4 0604
3 Months	1 0406	5.1010
6 "	1 0510	6 1520
9 "	1.0615	7 2135
2 *Years*	1.0721	8 2856
3 Months	1.0829	9 3685
6 "	1.0937	10.4622
9 "	1.1046	11 5668
3 *Years*	1 1157	12.6825
3 Months	1 1268	13.8093
6 "	1 1381	14 9474
9 "	1 1495	16 0969
4 *Years*	1 1610	17 2579
3 Months	1 1726	18.4305
6 "	1 1843	19 6148
9 "	1.1961	20 8109
5 *Years*	1 2081	22.0190
3 Months	1.2202	23.2392
6 "	1 2324	24 4716
9 "	1.2447	25.7163
6 *Years*	1 2572	26 9735

The practical use of this is illustrated below for two extreme cases:

	Case 1	Case 2.
PRIMARY PLANT		
Tonnage per quarter	7,500	7,500
Profit per ton	\$1 00	\$1 00
Quarterly profit (P T)	\$7,500 00	\$7,500 00
Fixed charges	30	1 00
PRIMARY AND SECONDARY PLANTS		
Tonnage per quarter	10,000	10,000
Profit per ton increased tonnage	\$1 30	\$2 00
Profit per ton on whole tonnage	1 075	1 25
Quarterly profit (P T)	10,750 00	12,500 00

Using the coefficients as above given and substituting the values of P T, we get the following:

	Cases 1 and 2. Primary	Case 1 Primary and Secondary	Case 2 Primary and Secondary
Tons	60,000		.
Time	2 yrs	1½ yrs	1½ yrs.
Profit	\$62,000	\$66,000	\$77,000
Plus interest for two quarters, compounded		67,000	79,000
Gain over primary		\$5,000	\$17,000
Tons	90,000		.
Time	3 yrs	2¼ yrs	2¼ yrs.
Profit	\$95,000	\$101,000	\$117,000
Plus interest for three-quarters, compounded		104,000	121,000
Gain over primary		\$9,000	\$26,000
Tons	120,000		.
Time	4 yrs	3 yrs.	3 yrs
Profit	\$129,000	\$136,000	\$159,000
Plus interest for four quarters, compounded		143,000	165,000
Gain over primary		\$14,000	\$36,000

By this comparison (of what may be a normal with an exceedingly abnormal case of fixed charges) is clearly shown the important part this fixed-charge item of Mr. Hoover's plays, a

part so important as to call for the careful segregation of all such items in mine accounting, so that the ratio of plant to reserves may be readily and constantly canvassed, without the necessity of a special and laborious investigation. Mr. Hoover's separate items of gain are all included "automatically" in the figures 14,000 and 35,000 (120,000 tons and four years, Cases 1 and 2), thus, 10,000 tons per year for three years equals 30,000 tons, the increased tonnage per year, and fixed charges for the two cases would be $9,000 and $30,000 respectively, and the several interest items amount to, approximately, $5,000 and $6,000; so that fixed charge plays by far the most important part.

While going with Mr. Hoover in the foregoing to the full extent of his argument regarding the maximum permissible ore reserves, I do not care to accede unreservedly to the proposition that the "maximum" provided as above should also form the minimum. There are certain classes of deposits that, from geological structure and occurrence, can be reckoned on more definitely, within their limits, than the standard quartz vein; there are also conceivable cases where the additional security of the investment would seem to be too clearly bought by keeping a three or four years' reserve blocked out Such would be the case of a mine with many small veins and heavy ground, where the additional charge for repairs and for interest on development would seriously impair the profits. With such particular cases in mind, the minimum proposition quoted does not appear so inevitable as the maximum, though it can be granted that in the majority of instances it affords a safe rule for practice.

R. Gilman Brown.

San Francisco, May 12, 1904

AMORTIZATION

(June 2, 1904)

The Editor:

SIR—The subject of "Mine Equipment and Ore Reserves" has been so well treated by experts in the JOURNAL that I hardly feel competent to join in the discussion from the scientific side. I would like, however, to say a few words on the question of amortization, which hardly seems to be understood by some of your correspondents. I feel further disposed to do so as some of my friends have asked for a little instruction on this point. The word amortization is French, but it is a good one to take over into English speech, as we have no single word which expresses the idea. Sinking fund does not cover it, for that is applied only to some special provision for the payment of bonded debt or debentures. As nearly as I can express it, amortization is the provision from earnings of a fund, independent of dividends, which will, in a given period, repay the original investment. To provide such a fund is not usual in this country, though it is frequently done in Europe; and in France, at least, it is required by the law governing the operations of incorporated companies.

A mining investment, in the great majority of cases, is a terminable investment, not a permanent one. That is, it will end and become unproductive after a time, shorter or longer, according to the nature of the mine. It is not a permanent investment, like a railroad, which may be expected to last and to return profits for an indefinite period. A mining investment, therefore, to be good, should return not only ordinary interest on the capital, but a further sum, sufficient to repay the original capital during the life of the mine. A railroad, for instance, with proper allowance for repairs and renewals, will probably be earning profits and be worth at least as much as now, twenty or forty years hence; and its owners will still have the security. But twenty or forty years from now the owners of a mine now

profitable may have nothing but some extensive excavations and a lot of machinery, which is likely, at the best, to be worth only its selling value as scrap. So with all mining investments; they run with the life of the mine, and the return should be large enough to equal the capital, plus interest, during that life, whatever it may be.

In France the usual custom, I believe, is to divide the amortization fund among the stockholders when the company has to go out of business. In Germany very little amortization is done, for the German custom is to nurse a mine and carry it along forever by taking as little out of it as possible each year. The exception is found in a few of the big coal companies, and they have amortization funds, which are usually applied to the purchase of more coal lands. In England they do not say amortization, for your Englishman has a strong propensity to call things by names that mean something else. But they have depreciation funds, surplus funds and whatnot, which amount to the same thing. There are various ways of using these funds. That most approved seems to be the purchase of new property, so that the company may be kept alive. Occasionally the funds, whatever they may be called, are returned to stockholders; this is often done by buying in, or paying off, part of the stock from time to time, so that the capital stock is reduced gradually, as the mine decreases in value. The continuance of the company, with a new property, seems the favorite method, however. The Englishman is cosmopolitan in his investments, and there are sometimes curious changes. Thus, some years ago, a company which had been mining in Idaho gave up its exhausted property and bought a mine in Western Australia, still retaining its old name. Such instances might be multiplied.

Except in France, there seems to be no uniform rule as to the manner in which payments are made to amortization funds. The fairest and most uniform method seems to be a fixed charge on ore mined, based either on quantity or on value, according to the nature of the mine.

In this country amortization funds are not usual. The general practice is to pay out surplus in dividends, leaving each stockholder to make his own amortization, if he is disposed to do so—usually he is not. This is based on the continual shifting of stock ownership. With few exceptions the American investor

does not buy mining stocks to keep. He sells them when he has a chance to make something. It has been said that the ownership in an American mining company changes, on an average, every five years; and, quite probably, this is not far from the truth. Under these circumstances, it is quite natural that a stockholder should prefer to get all that he can out of his shares while he holds them, without looking to the future.

An exception is found in some coal and iron companies. Thus the Delaware & Hudson Company includes in its expenses a fixed sum per ton of coal mined, which goes into a fund which has been, up to date, used to pay off the company's mortgage bonds. These are now nearly all retired. The Reading Company has done the same thing since its last reorganization. The Pittsburg Coal Company has a similar charge on earnings, the sum thus set aside being used chiefly to buy new coal lands. In the last-named case the amount has been calculated on such a basis that the fund will replace the coal lands mined out each year, and so keep the company going as long as there are new lands to be bought.

Among iron companies, several of the larger Southern companies also make a charge to earnings based on the iron ore and coal mined each year. The Sloss-Sheffield Company, in addition, makes a charge of 25c. for each ton of pig iron made, the fund being used to renew its plant. The Oliver Iron Company, which is the iron mining branch of the United States Steel Corporation, has a system of charges based on ore mined.

In none of these cases, however, except the Delaware & Hudson, are these funds applied to reduction of capital, and they are not, therefore, properly amortization funds. The iron mining companies referred to also own manufacturing plants, and it is essential to their operation that the supply of ore, or raw material, should be kept up. The retirement, or repayment, of capital is not considered in the matter.

On the whole, I do not think that American buyers of mining stock will take kindly to amortization funds, under present conditions. They prefer to trust to themselves, and to the chance of selling their stock, to allowing the company to look after the repayment of their capital at some indefinite future date. As long as this feeling lasts the practice of amortization can hardly extend.

Some day we may take time to think a little about it, and then I believe the justice and reason of the plan will be realized. And it may do something also to promote permanence and stability in mine ownership—which is a thing much to be desired

F. HOBART

New York, May 10, 1904.

VALUATION OF GOLD MINES

(June 9, 1904)

The Editor:

SIR—I agree with Mr. Hoover in his interesting article of May 19, that every mine is a problem in itself, there are no fixed principles by which the appraiser may be guided to a definite and correct value by the rules of mathematics. Because if he deals with averages, or laws of probability, as to the life and profit of such gold mines in general, or even of the mines in a special district, he will as a rule arrive at very erroneous results. It is one of those cases in engineering practice where experience, skill and judgment are of the utmost importance to get even an approximate solution.

The method which I have found most satisfactory is about as follows: Having correctly valued the ore in sight, the size, shape and relative positions of the orebodies should be mapped to scale, and compared with those of the exhausted orebodies for at least three years previous. Then, by comparison, try to find the law of continuity and value. Next, by that law, together with a study of the history of the most developed mines in the district, decide on a definite figure for the undeveloped portion of the mine. Having thus arrived at a definite value for the whole mine, the next question to consider is the economic ratio of development to milling capacity. Then the gross profits in the mine and the time necessary to exhaust the same. Lastly, an estimate should be made of the extra capital necessary fully to equip and develop, to reach the economic ratio. Having found all these, the extra capital should be subtracted from the gross profit, and the balance capitalized, so as to yield 10 per cent per annum during the time necessary for exhaustion, and at the same time redeem the principal.

As an illustration, let us take the 15 Westralian mines, which Mr. Hoover says have a gross profit in sight of about £10,000.000; and suppose the appraiser adds another £10,000,000 for profit in

undeveloped ground. Now, if he considers £2,000,000 necessary to put those mines on an economic ratio, so that they would be exhausted in 30 years, then his valuation would be £4,500,000, instead of £14,500,000, as Mr. Hoover makes it. Because £20,-000,000 — £2,000,000 = £18,000,000. And £18,000,000 capitalized at 10 per cent per annum for 30 years, with the principal redeemed during that time, is represented by £450,000 × 30 + £4,500,000 = £18,000,000, the total amount of profit in the properties mentioned.

Mr. Hoover thinks that 6 per cent is sufficient interest to pay on mining investments, but I think most engineers will agree with Mr. Curle that 10 per cent is a fair figure, over and above the redemption of the principal.

There is another question in the valuation of mines of every kind which is of sufficient importance to be mentioned here. And when the time comes that Prof. Church says ought to come if investors wish to be protected, when the president of every mining company is a qualified mining engineer, then every mine will be valued annually by an independent engineer, just as the books are audited by an independent accountant. I trust the Institute of Mining Engineers will take this matter up, and have a law passed compelling mining companies to have their inventories and valuations tried by an independent engineer before the auditor will accept them.

ROBERT STEVENSON.

New York, May 25, 1904.

MINE EQUIPMENT AND ORE-RESERVES

(June 23, 1904)

The Editor:

SIR—The article on ore-reserves and mine equipment by Mr. H. C. Hoover covers the particular field discussed by him with such skill that it seems to me there is not much more to say. Unfortunately most of us do not have the opportunity of unraveling the problems pertaining to the exploitation of such magnificent mines as those which Mr. Hoover directs, nor do we operate with the reserve capital of such strong companies as those with which he is connected The mining future of this country depends to an ever-increasing extent on the profitable exploitation of relatively small, erratic and low-grade deposits; in other words, in making hard propositions pay. The West has been pretty well run over, and it is probable that most of the big things are already under process of development; and while, of course, some of us will be working bonanzas for several generations, the vast majority of mining engineers will be continually up against a hard game. It is the problems pertaining to the successful operation of such deposits which more vitally concern the majority. To my mind there is more credit due to those who take up the hard propositions and make them pay than to those who exploit bonanzas along finely scientific lines; the first usually require energy, sagacity, perseverance and, very often, *daring*; while the other need chiefly cool calculation. The acquiring and early development of the bonanza is a different matter; in this achievement much the same qualities are called for as in the operation of a hard proposition. But only a few of us, as already stated, will ever have the opportunity to acquire a bonanza for ourselves or clients, so we may just as well look the facts in the face and consider the problems incident to the operation of that large class of deposits with which most of us are more or less directly associated. In such cases the amortization of the equipment becomes an even more serious problem than in the instances

discussed by Mr. Hoover, for it becomes doubtful whether the expenditure will ever be amortized at all, rather than a question of how many months will be required to get even. And yet conditions of operation, as they exist, often force an expenditure for equipment before one can figure the ore reserve to justify it. It may be necessary to equip and begin production, or quit altogether. In such cases I think a man is justified in using the most temporary expedients, rather than in providing such an equipment as would be called for if a long campaign were actually assured.

It has been my observation that more mines are killed by too much equipment, and ill-advised equipment, than from errors in the opposite direction. The tendency to make large expenditures to assure a low working cost per ton has been at the bottom of many a mining failure, because the hard facts of the limited number of tons available and the utter worthlessness of abandoned mine equipment were both entirely overlooked. The sure loss of operating with inefficient equipment and the possible loss of expending too much on equipment, present the Scylla and Charybdis of this feature of mine management; the admirable sailing chart compiled by Mr. Hoover will guide the big steamers with scientific accuracy; but the pilot of the little sailing vessel, driven by fickle winds and diverted by unseen currents, cannot follow the directions, and under such conditions success is the more admirable and failure the more pardonable.

It seems to me that the question incident to providing the ordinary mine with equipment does not permit of any very extended discussion, along general lines, because nearly every mine has its own individual problem, and those that haven't, fall without question under Mr. Hoover's rule; but there is an infinite variety to the problems confronting the average mine manager, and the successful solution of hard problems of management makes the basis of what is to many of us the most interesting form of mining literature. The consideration of the difficulties that have beset our fellows and of the means they adopted to overcome them is sure to be of practical service sooner or later; and in the hope that I may be able to start the ball a-rolling in this direction, I will mention three instances out of my personal experience.

The estate of W. S. Stratton, deceased, included some 713

acres of territory in the Cripple Creek district of Colorado. There is little of this territory from which there has been no shipment of ore, and some parts of it have made a large production. The pay ore is found in isolated bodies scattered through a perfect network of veins, contacts, and mineralized dikes. The grade of the ore at Cripple Creek is comparatively high, so that a relatively small orebody may be of considerable economic importance. As a consequence of these conditions, the problem of finding the ore very much overshadows any other problem in the exploitation of these deposits The successful "ore-finder" is the man who makes an exhaustive study of a given locality and then watches every little indication as work progresses. The failure to follow off into the wall the smallest stringer that assays may mean the loss of a good orebody. The most successful "ore-finders" in the camp are the small "leasers," whose self-interest calls forth a degree of astuteness and careful attention to detail which is not obtainable in a paid force. Therefore, I recommended that the territory which was not developed by deep shafts should be leased in surface blocks, and that a large part of the territory that was developed by deep shafts should be let on the tribute system. This plan has been slowly put into effect, and, thus far, the results are highly satisfactory.

At the Golden Cloud mine in Montana the vein is small, remarkably continuous and of exceptionally uniform value. The average grade is $25 per ton in gold and the property is equipped with a good mill. The quartz is soft and frozen to the walls, and the problem to be solved was how to mine this ore cleanly at a cost sufficiently low to leave a margin of profit. When working on day's pay the miners found the quartz very nice drilling ground and shot it all to pieces, so I put them on a contract system whereby each pair of men had a certain block of ground and were paid so much per ton of clean quartz delivered at the mouth of the tunnel. The system has proved satisfactory thus far.

At the Cornucopia mine in eastern Oregon in 1896 the principal problem to be solved was the successful milling of a rebellious ore. Mr. T. A. Rickard, as consulting engineer, was in control of operations. My position was a subordinate one. The ore carried part of its values as free gold, part as silver, gold, copper and lead in pyrite and part as telluride of gold. When Mr. Rickard

took charge there was a 20-stamp mill on the ground equipped with six vanners, the product of which was chlorinated, with a heavy loss, mainly in the roasting stage of the process. This loss had been undetected by reason of stupidity in calculations, which failed to allow for the decrease in weight by elimination of moisture in roasting The shipment of the concentrate to the smelter at Tacoma gave larger profits, but even then the extraction was poor, by reason of the values escaping in that part of the tailing which would pass a 100-mesh screen. Mr. Rickard and Mr. Barnhart, the superintendent, then decided to introduce hydraulic separators, two more vanners and a canvas slime plant, so that the extraction was increased from 65 per cent to 85 per cent, and the mine became a profitable enterprise. The essence of this success was not only in the improved extraction which was attained at every step of the milling process, but in a general reduction of working costs carried out by the superintendent

GEO. J BANCROFT.

Seattle, Wash., June 10, 1904.

THE ECONOMIC RATIO OF TREATMENT CAPACITY TO ORE-RESERVES

(July 14, 1904)

The Editor:

SIR—Under the above heading appears an article by Mr. H. C. Hoover in your issue of March 24. As this subject forms one of the most important of the financial problems with which the engineer has to deal, it would be advantageous to have it fully discussed and ventilated by men in different parts of the world, and I put that view forward as my excuse for the remarks that follow.

The general impression made upon my mind after carefully reading through Mr. Hoover's article is that while keeping the main issues well in view, he is somewhat obscure as to the basis of his reasoning, and as to the many contingencies for which provision must be made before the well-known maxims which he expounds can be practically employed. It may therefore be well to further discuss some of the questions he has raised, with a view to greater elucidation and further suggestion.

Mr. Hoover states as a preliminary: "Starting with an assumption of unbroken continuity to their utmost boundaries, our South African friends need but little outside of compound interest tables upon which to found their finance. In the great majority of mines, however, the result of development at their lowest levels remains speculative and gives a zest such as an assumed persistence can never afford." It seems to me that Mr. Hoover has imbibed the popular idea that the art of mining on the Rand is conducted upon such simple lines, owing to natural conditions, that, as he says, "our South African friends need but little outside of compound interest tables upon which to found their finance." It should be understood by engineers, at least, and I affirm it now, that the mines of the Rand are subject to as extreme fluctuations in value as deposits of any other kind, and that it is equally necessary on these fields to develop skilfully and far in advance of the mill as upon any other goldfield, if

any knowledge of the conditions governing the problems discussed by Mr. Hoover is to be acquired.

The essential difference between the Rand "banket" beds and metalliferous deposits of differing origin is, that in the former we are not called upon to contemplate the complete disappearance of our values within the limits so far worked—a contingency which always has to be reckoned with in other forms of deposit. It is just as necessary, however, that reserves should be well ahead of mill requirements for the consideration of the question of the ratio of treatment to ore reserves, otherwise for one period the mines would be earning large profits, and for another they would be working at a loss On the Rand, equally with other fields, we must consider the possible rate of development, which is governed by the facilities for attack, the ore exposed per foot driven, and the percentage of payable ore to the total developed

In some sections of the Rand, the reef averages less than 6 in. wide, and, if in such cases the proportion of payable ore is as low as 30 per cent, and if the development scheme is rendered bad, as is the case in some instances, by faults or dikes, then it is clear that the plain sailing which Mr. Hoover believes is an essential condition of mining work here, is an erroneous conviction.

In the second paragraph of his article Mr Hoover states "that the most economical and profitable treatment capacity is the maximum capacity which can be employed, is not difficult to demonstrate; that the maximum must depend, however, upon the speed of development, and that the speed of development must be pushed as fast as the limitations of nature will permit, is but to state a corollary. Yet, curious as it seems, the number of mines which have been operated upon the principle that the mill is the fixed quantity and the mine the variable, exceeds the number conducted upon the reverse plan." This sentence aptly illustrates my view as to the obscurity of Mr. Hoover's basis of reasoning. The statements are entirely true, but there is a variety of principles involved which cannot be thus settled by a stroke of the pen. Firstly, we must consider the financial status of the company operating, as to whether it is in a position to make the monetary arrangements necessarily involved in a scheme for expansion. Let us take a case as an example. Assume a company owning a property which requires £500,000 to bring it to the pro-

ducing stage on a basis of 100 stamps. To find such a sum of money might not only exhaust all the cash resources of the company, but cause it to overdraw to the extreme limit of its credit. Let it be assumed that the company has commenced milling and is earning profits. It is now suggested that it should accept Mr. Hoover's dictum "that development must be pushed as fast as the limitations of nature will permit." To carry out the suggestion one of the following alternatives might be adopted. either a loan to cover excess development, or profits might be utilized for the purpose of extra development. As the company is assumed to have no further credit, it cannot adopt the first alternative, and for the same reason in this instance it would not be likely to adopt the second. The further view, that current profits should be utilized for the benefit of the later shareholders, would also be contested by the present shareholders, who naturally would want a cash distribution as soon as such was available.

In this instance, therefore, although Mr. Hoover's dictum is in every sense correct, it would be impossible to accept his policy. The basis of reasoning must therefore include:

1. Financial credit.

2. An agreed basis of arrangement as to the manner in which the capital will be raised, namely:

(a) Whether as a direct loan.

(b) By the issue of reserve shares.

(c) By the utilization of current profits.

(d) By increasing the company's capital.

As he leaves the reader to guess these alternatives it has seemed to me pertinent to mention them.

Mr. Hoover well remarks, in the concluding sentence of the quotation I have made, that the mill is in general regarded as the fixed quantity and the mine as the variable. In my "Deep Level Mines of the Rand," it was shown that if a company running a 200-stamp mill on a mine with a 20-years' life earned an annual profit of £336,000, the present value of the total profit of £6,720,000, allowing 6 per cent for dividends, and 3 per cent for amortization of capital, would be £3,456,768. If, however, the total amount of £6,720,000 is discounted as a yearly dividend of £672,000 for ten years on the same basis as before, the present value of the amount becomes £4,564,224, or £1,107,456 greater than the same amount earned in a 20-year period. In other

words, if the milling equipment is increased at intervals, and the mine worked out in ten years instead of twenty years, the net gain, even after allowing for extra expenditure for increased equipment, in the instance taken, is materially increased.

It is difficult to get the financial controllers of mines always to follow the engineer in this respect. They object that there is a constant shifting of the financial basis, while there is new equipment to be erected, and excess development to be accomplished, and, strangely, they have a sentimental liking for a longer life, which has the one element of possible participation in improved working conditions to recommend it. If the engineer can see beforehand that the property to be worked is one likely to lend itself to a scheme of this kind, he can suggest to the financial heads the provision of reserve shares, which can be issued from time to time to meet the capital requirements, and thus the current earnings of the mine are not diverted.

Mr. Hoover says: "We now divide the various charges against working expenses into: First, those charges variable with tonnage, such as development, haulage, treatment, etc., and second, those charges, usually referred to as 'fixed,' which depend partially upon the element of time as well as tonnage, and include, partially or wholly, pumping, management, amortization of capital invested, etc." Although not entirely relevant to the subject under immediate discussion, some remarks upon this and kindred heads may not be out of place. The development charge on a mine is one susceptible of very diverse treatment. There are, however, two methods which are legitimate, and properly suit special conditions. The variation in the conditions arises out of a question of policy, which again may be dictated by the financial resources at command. One engineer may recommend that the mine be developed for a mill of fixed capacity and to such an extent before milling begins, that there will be no subsequent necessity to develop at a more rapid rate than the mill requirements, that is to say, the total ore reserves are practically unchanged. In such a case the cost of development is rightly charged to working account as a lump sum. For the same property as above assumed, another engineer may recommend development of the mine on a comparatively low basis, and two years ahead of the mill. He may question the soundness of a policy of sinking large capital sums in development work many years ahead of require-

ment, because the interest on the sum should rightly—although in practice it is not—be charged against the developed ore

After the mill starts, the policy laid down provides for rapid excess development and periodical increases to the equipment, for which policy the necessary financial provision has been made. As the rate of development might easily absorb the total working profits, the latter are not diverted, but the development work is paid for out of the capital each month. At the end of the year the accounts are made up and it is found that, say, 200,000 tons of ore have been developed, costing £50,000. The working charge per ton milled would, therefore, be debited with an amount of 5 shillings per ton—the cost to develop—in order to gradually redeem the development at cost.

The question of amortization of capital in a mining undertaking is a very difficult one, and I cannot follow Mr. Hoover in his view that it should be made a fixed charge against working costs Amortization can only be fixed on a definite knowledge of the profitable term of an undertaking. If a mine be figured to have a life of ten years, and it ultimately proves to have twenty, or vice versa, the charge for amortization will in the first instance have been too heavy, and in the latter too light. The best principle is that the company should not, as a company, attempt to amortize. The value of its shares on a given earning, on the basis of amortization of capital or otherwise, can be readily computed by the investor. If the company puts aside an annual amount as amortization, it naturally reduces the distributable profits, and these might possibly, if distributed in full to the shareholder, be reinvested by him with immediate benefit Moreover, if investors, who bought interests in the earlier stages of the mine, sold out at a later date, the profits which they should have received would accumulate to the advantage of the investor who bought during the later stages of the company's career, and thus the former would be at a disadvantage, unless the market appreciation of the company's policy of amortization were fully reflected in the share value throughout. It should be the business of the shareholder in his individual capacity to amortize his investment, but not that of the company in its corporate capacity.

Mr. Hoover says: "In these cases less than three years' accumulation of the increment of profits is required to amortize the entire capital involved." He does not explain how he will

deal with the amortization. If it is written off profits, the future shareholder benefits to the prejudice of the present, and there is a reduction of dividend for that period which may affect the price of the stock. If the secondary equipment be paid for out of capital the earnings on the greater capital sum entailed must be considered.

I cannot follow Mr. Hoover in his treatment of amortization of outlay on plant. I take it that a good plant on any mine has a life of not less than seven years, and with proper care and sound maintenance much longer. Let it be taken, however, at seven years. Now, if the cost of plant, as suggested by Mr. Hoover, is written off in three years, there would appear to be a loss on the transaction, unless the added profits will amply compensate for the potential loss in plant The figures as he gives them show only about a similar net result, in the cases of the primary and secondary equipments, after deducting the capital outlay on the latter. The sole advantage would then be the difference in the present value of the ultimate profit earned, and if we take it that this is £100,000, the advantage of earning it in three years instead of six represents, on a basis of 6 per cent for dividends and 3 per cent for amortization, £9,210. Mr. Hoover takes it that on the primary basis a three years' reserve should be figured upon. If the development increased so rapidly that a six years' reserve is built up (although he does not suggest how he arranges his finances in the meantime), then, if I read him aright, he would add secondary equipment to such an extent as to make the reserve again three years. But supposing that no more payable ore were discovered, then it seems on his own showing that, saving the aspect of the increased present value of the profits, there is no special advantage in the scheme.

Suppose, for instance, we have a 100-stamp mill which crushes 168,000 tons per annum. A reserve of six years for such a mill would be 1,008,000 tons. Now, if we build another 100 stamps and utilize the increment of profit to amortize the outlay we get a result somewhat as follows:

Cost of 100 stamps, "secondary equipment," and all accessories, including power, etc .	£100,000
Additional water supply, pumps, etc .	10,000
Additional buildings, quarters, etc .	10,000
Total	£120,000

Assume profit on the 100-stamp basis to be 10 shillings per ton.

Assume profit on the 200-stamp basis to be $12\frac{1}{2}$ shillings per ton, the increment of profit due to adding 100 stamps is:

Total profit earned on 100-stamp basis in six years, 1,008,000 tons at 10s per ton.	£504,000
Total profit earned on 200-stamp basis in three years, 1,008,000 tons at $12\frac{1}{2}$s .	630,000
Total increment of profit . .	£126,000
Total cost of secondary equipment . .	120,000
Balance, profit . .	£6,000

If interest be added to the capital outlay incurred for the secondary equipment, the balance shown will disappear.

In mines of uncertain continuity in depth it would therefore appear necessary to make a more conservative ratio of equipment to ore-reserve than that mentioned by Mr. Hoover. If, as I have suggested, the payable ore were suddenly to give out when sufficient reserves to provide an increment of profit that would just amortize the capital outlay in additional plant had been secured, then the mine would possibly be prejudiced in the following way. All mines are found in practice to contain the ore in shoots, streaks, pockets or patches. As the workings progress it becomes clear that a process of selection has been in practice, by which ore falling below a certain standard in grade is allowed to remain in the mine. The longer the mine is worked the greater becomes the aggregate tonnage of more or less developed ore of a grade falling below the arbitrary limit of payability. It is a truism, however, that in every mining field the costs of production vary directly with the age of the field; in other words, there is a practically continuous reduction in costs year by year. In the instance I have previously assumed of a mine having a final reserve of six years' payable ore on a "primary" basis, it is probable that large quantities of ore left in the mine which are unpayable during the first of the final six years would, through decreasing costs of production, improved methods, whether mining or metallurgical, fall within the limits of profitable working before the first year's work, and therefore the mine would, under these conditions, secure a new lease of life, on ore of a grade which if worked out in a three years' period would still be unpayable, despite the lower operating costs of an increased installation. There should, therefore,

be a big margin of increment of profit allowed over and above the amortization of plant amount, and even then I doubt if the scheme is a satisfactory one, notwithstanding that the objects aimed at are undoubtedly desirable.

It appears to me obvious that in mines of uncertain continuity in depth there can be a definite and satisfactory basis of ratio of equipment to ore-reserves established, but on a plan different to that proposed by Mr. Hoover. The conditions of such mines call for very advanced development, not only to enable their future possibilities to be gauged, but to put the operators in a position to average up, over the widest possible area, the grade of the ore developed, in order that steady outputs may be maintained. Further, by such a scheme it is possible to include a large tonnage of ore near—but just below—the arbitrary limit of payability, which would inevitably be untouched if the mines were worked on narrow margins of development.

After all, the whole matter under discussion rests upon the courage and resources of those who control the finances of the company. Every engineer has experienced a difficulty at some time or other in persuading the financial heads of a mining business to carry development even one year ahead of the mill, owing generally to shortness of funds. If they can be persuaded to follow the advice of the engineer I believe the right policy to be the following, which I submit with all deference:

It is assumed that preliminary prospecting has been finished and a scheme for permanent work is to be provided.

First Step. — The mine to be opened out for examination, to such an extent that data for a sound development policy can be formulated.

Second Step. — A development policy framed, including estimates of cost; time to carry it out; and probable tonnage and value of ore that will be opened up.

Third Step. — From the information to be gained as the development proceeds, a justifiable limit for ore-reserves to be fixed, taking into account all the variables of width of reef, percentage of payable ore per 100 ft. driven, and facilities for attack.

Fourth Step. — A mill of a capacity fixed by the limit of ore reserves to be erected, which reserves should not be less than the total which the mill would crush if worked continuously for two years.

Fifth Step. — Development to be continued, at least at the milling rate, on payable ore.

For the time being these are all the steps which in a sound policy can be formulated. The mine now works steadily ahead for a couple of years (more or less, as the circumstances decide), proves its ability to make a profit on this basis, and the question of further additions is suggested by the engineer. Before these additions can be agreed upon by the financial heads they must settle the details of the scheme by which they propose to finance, which will be one of the following:

A. Diversion of current profits.

B. Temporary loan to be paid out of profits, over an extended period.

C. Increase of capital of the company.

D. Issue of already existing reserve shares.

Of these, the last named is in my opinion undoubtedly the soundest and most equitable to all shareholders, for reasons which I have explained many times in other writings.

Sixth Step. — The engineer, having gained by experience a full knowledge of the mine and its capabilities, suggests that development should be advanced at such a rate that the excess tonnage of payable ore (over and above that required to maintain a stipulated reserve for the primary equipment) should at the end of a given period allow for a liberal margin—say six years—on an additional unit of reduction and treatment plant. Assume that the primary unit is 50 stamps with a three years' reserve of 252,000 tons of ore, and assume the first addition to be 10 stamps, requiring a reserve on a six years' basis of 100,000 tons, then when the 60 stamps begin working the reserve would stand at 352,000 tons, equivalent to 3.5 years. Development would again be pushed—provided always that the conditions permitted—to such an extent that the reserve of 3.5 years would be maintained for 60 stamps and excess tonnage gained to give six years' reserve for an additional 10 stamps, when the latter unit could be added, bringing the mill capacity up to 70 stamps and the ore-reserve to 3.8 years' work for the whole mill. The same process would again be followed through, and the net result would be a gradual gain in milling power, and with each unit of addition of plant, an advance in the ratio of reserves. When five years' reserve has been built up on the lines above indicated, by which

time the mill will contain 150 stamps, the question of increasing the units of addition from 10, the standard up to this point, to 15 or 20 stamps can be safely considered, and thus throughout the mine will maintain a legitimate and perfectly sound ratio between ore-reserves and equipment, and will fulfill the essential requirement of winning the ultimate profit from the mine in the shortest time consistent with sound and prudent management.

It will doubtless be said that the scheme I have outlined—indeed this whole question—is too elaborate for consideration in connection with the ordinary mining "prospect," because mines are frequently opened and worked by people with limited means at their command, to whom it is vital that the producing stage should be reached at the earliest possible moment, without regard to the question of ore-reserves One has to admit that the industry of mining can be conducted on widely varying principles, and expediency will often ride rough-shod over systems; but mining business which is conducted upon the method of expedients, although perhaps it is a necessary stage of such a business, cannot be regarded as either safe or substantial, and if the principles which this article is intended to elucidate do not apply in any given case, then I think so much the worse for that case.

G. A. Denny.

Johannesburg, June 6, 1904.

EQUIPMENT AND ORE-RESERVES—IV

(Editorial, July 21, 1904)

THE discussion upon this important subject has been revived by the valuable contribution from Mr. G. A. Denny, which we published last week. Our readers will join with us in appreciation of so earnest and thorough a presentation of his views. Such discussion fulfills one of the highest purposes of technical journalism.

Many aspects of the inquiry were touched upon in the letter referred to. One of them calls for present notice. Mr. Denny demurs to Mr. Hoover's suggestion that the banket of the Rand is so uniform in persistence and in the grade of ore that mining finance in South Africa is shorn of all the bristling dangers arising from the vagaries of ore deposition elsewhere. Both of these experienced engineers are right, relatively; for it is altogether a matter of comparison. The reefs of the Rand, in their uniform tenor and continuity, do somewhat resemble coal seams—more than they do "gash-veins," for example, lenses in schist, or "pockets" in limestone. As compared with these types of uncertainty in ore occurrence, they are strikingly regular and calculable; and yet when judged by such a standard of uniformity as a coal seam, the gold-bearing lodes of the Rand vary within margins wide enough sometimes to try the nerves of cautious financiers. Recent events have emphasized this. The shares of the Bonanza company fell from £6¾ to £2, because the grade of the ore opened up declined so much that the estimated life of the mine was reduced from over four years to about 20 months. This is one of the shares which have been authoritatively considered as certainties, outside the limits of ordinary speculation. On the other hand, the life of Crown Reef has been extended in estimates from seven years' supply of ore for 120 stamps, to 14 years' supply for 240 stamps, simply because previous calculations had only included the material to be obtained from the South

Reef and the Main Reef Leader, while later developments have demonstrated that the wider Main Reef itself can be reckoned upon for an exceedingly big tonnage of payable ore. Facts such as these indicate that plans for equipment are likely to be disturbed by the unforeseen even at Johannesburg. Indeed, we doubt very much if gold mining would have half the zest to the investor if the element of speculation were entirely eliminated, and it is well at all times to emphasize the essential distinction between even the best mining venture and the securities, such as first-class bonds, the safety of which is, humanly speaking, guaranteed Bonds give absolute safety and a very low rate of interest, mines yield a high return with an inevitable risk; in some cases the risk is small and the return is large; in others, otherwise. Both are equally legitimate as investments As mining becomes freed from foolishness and develops on a sound basis, mining shares tend increasingly to attract shrewd men because the proportion of risk to return becomes lessened, while in the case of bonds, that relation becomes less attractive because the safety remains no greater, and no less, while the plethora of trust funds slowly brings about a fall in the rate of interest receivable.

EQUIPMENT AND ORE-RESERVES—V

(Editorial, August 4, 1904)

In a recent discussion of this subject, reference was made to the diminution in working costs as a mining region grows older. Anyone inaugurating a mining enterprise may well afford to consider this factor, before planning for a lessening of expenses on the basis of a large and costly equipment. It is not always realized how great is the drop in costs which follows upon the improved conditions consequent upon the growth of a goldfield. In 1894 the average cost of realizing upon the gold per ton of ore shipped from Cripple Creek must have been fully $40. At that time the smelters charged $15 per ton for treatment, the railway took $5 per ton, and these deductions, with the higher cost of supplies and machinery, made a fearful inroad into profits. Only high-grade ore could be handled, sorting was necessary, and this multiplied the original expense of mining. Within five years the smelter rate went down to $6.50 and the railway charge to $3; and in later years the erection of large, centrally situated chlorination and cyanide mills, competing in the ore market with the smelters, brought the total charge for both transport and treatment to a minimum, on low-grade ores, of $5 per ton.

In Western Australia, in 1897, the costs in the outlying goldfields averaged more than the value of an ounce of gold. The scarcity of water, the dearth of timber and its transport from elsewhere by camels, the distance from distributing centers and the want of experience in the metallurgical treatment of the ores—all these factors united in rendering expenses so high as to kill the mining of medium-grade ores. Within a couple of years the extension of the railways, arrangements for securing water from idle mines and the skill put into the milling methods, reduced costs by 30 to 50 per cent. This was done without any increase of equipment.

The minimum figures of recent years are, of course, the result,

in large part, of better equipment and a larger scale of operations; but, quite aside from this factor, the general conditions existing during the earlier years of mining in Western Australia and in the Cripple Creek region changed for the better so much, that, on the same tonnage and the same equipment at the same mine, the expenses went down within five years to the extent of fully 50 per cent. That is, to put it plainly, at Cripple Creek costs averaged $40 in 1894 and $23 in 1899; in the outlying districts of Western Australia they averaged $22 in 1897 and $10 in 1902. It is obvious that the increment of profit to be gained from a larger output would have been exceeded during this period by the economies due to the rapid improvement in local conditions, and that a management which deferred the enlargement of its equipment would have won a larger final profit than one which wasted its ore-reserves in meeting the heavy expenses incidental to the youth of a mining district.

The subject is one to which we will return. It is well to add that the high costs at Cripple Creek were due to the fact that of the ore mined not more than one-third underwent shipment; even in rich mines one-half was sorted out, in others as much as three-quarters or even more. Thus the cost was high per ton of ore realized. This was due to the nature of the ore occurrence. Costs are now about $14 per ton as compared to $23 in 1899, not so much because general conditions have gone on improving, but by reason of the larger capacity of the custom mills and the bigger proportion of those low-grade ores on which treatment charges are relatively low. In Western Australia, similarly, since 1902 the beneficent results of the Coolgarlie water scheme, the extension of the railways, the improvements in ore reduction and the sense of stability due to the opening up of large reserves of ore have warranted estimates of an increment of profit due to larger equipment, and today even an outlying mine like the Cosmopolitan exhibits working costs as low as $5 44 per ton, inclusive of development and taxes.

Considerations such as these prove that the solution of the problem—the ratio of equipment to ore-reserves—must be determined by the local conditions of each case, and not upon general theory, however well founded. But a working theory is quite necessary, in order to start with intelligent ideas upon the subject.

ORE-RESERVES IN GOLD MINES

(August 4, 1904)

The Editor:

SIR—I have just been re-reading Mr Hoover's articles of March 24 and May 19, and, if not too late in the field, I will make a few remarks on some points raised by him.

Mr. Hoover says that "the maximum profit from any (gold) mine can only be obtained by the most rapid exhaustion of the mine, and that most rapid exhaustion is to be secured only by the most vigorous prosecution of development and the maximum equipment that can be employed." He then goes on to show—as a result of carrying out this system—that an economic limit to a mine's ore reserves intrudes itself as a factor, and that this economic limit works out at about three years. From the technical point of view I feel sure that Mr. Hoover's arguments are correct. They are unanswerable, and cannot but be endorsed by technical men.

Now let us look at ore reserves from the point of view of those who buy the shares. What do they say? It is a true saying that "those who pay the piper call the tune," and as the investors in gold mines furnish the capital wherewith the industry is kept going, it is only right that their side of the argument should carry weight. I will assume that these people know as much about sound finance as Mr. Hoover does about economic mining—indeed, you will find H. C. Hoover, Esq., the capitalist, among their number.

The argument of one of this investors' class would be as follows: "I have money to invest and intend to put it in gold mines. I have a sound knowledge of finance, and believe that, besides the value of any capital in the mining industry, my personality will have a sound and steadying influence on a class of securities hitherto held by many people in disrepute. But if I come in, and find money, I bring in with me my knowledge of sound finance, and I insist that the investments placed before me shall conform

to a certain degree of safety, which degree I, not you, shall decide. I see that from the technical point of view Mr Hoover's claim for an ore-reserve of only three years is sound; but I, who am asked as a consequence to risk the greater part of my capital on the chance of finding ore that is not yet exposed, and knowing the risks of mining, decline to go in on such terms. As a sound financier I wish to insure my capital, and I can do so to a great extent by insisting that there shall be ore-reserves for considerably more than three years ahead. I know that this is not the most economical way of handling the mine, and that there is a loss of interest on the money locked up in these extra reserves; but I look on this loss as the price I pay for insuring my capital, and am satisfied to incur it. If my terms don't suit you, I will withdraw from gold mining, and the gamblers and charlatans who have in the past made this industry their hunting ground can return."

Under ideal conditions of investment a three years' ore-reserve, as required by Mr. Hoover, would really be enough, for the shares would be capitalized only at such a price as to yield 30 per cent to the investor, who would then, on his three years' reserves, have the respectable proportion of 90 per cent of the mine's market capitalizations in sight as net profit. But in a mine that is located in a good district, with big orebodies, and looking well in the bottom, such a yield as 30 per cent is now impossible to secure. If such a mine can be bought into, to yield 15 per cent, it is as much as the investor can look for; but more often the yield of interest on the price of standard gold mines is found to be no more than 12, 10 or even as low as 8 per cent. Personally, I have come to the conclusion that the best gold mine should return 15 per cent to an investor, of which he must set aside at least half for the redemption of his capital; if the mine is not looking well in depth the rate of interest received ought to be considerably more.

Mr. Hoover's second article discusses ore-reserves in their relation to mine valuation. He says, with truth, that it is rarely possible in the initial stage to find a mine with a net profit in sight equal to the price asked for it. I had said that it is rarely possible to buy shares on this basis in a producing mine, and we had both tried to answer the question, What margin of risk is it permissible to take? Mr. Hoover argues that this margin of

risk ought to be determined differently for individual mines, and gives most ingenious theories for arriving at this unknown factor—theories based on locality; geologic structures, the nature of ore-shoots; width, length and value of the orebodies—all of which must be assessed at their just value and added to the net profit then in sight. I had previously (in estimating the chances of the average sound gold mine, over and above its present net profit in sight) lumped all these possibilities together as a job lot. My formula is that a share is worth buying if the net profit in the mine—assuming developments in the bottom are normal as to width and value—is equal to two-thirds of the market price of the mine. That means that I expect enough additional ore will be exposed in depth to at least return the one-third of the capital which is unguarded, and also pay a good interest on the whole of the capital at stake. This generalization of mines strikes Mr. Hoover as somewhat crude. But let me point out that it was written for laymen. The average investor, so far as I can see, has no standard to guide him, and is liable to flounder most hopelessly when he buys mining shares. The mere putting into operation of this bit of advice, and thereby reducing mine capitalizations to one-third more than the net value of the current ore-reserves, would alter the status of mining investments out of all recognition. In other words, to produce a paradox on one of Mr. Hoover's favorite expressions—amortization would set in, and the investing body, instead of dying, would be on the high road to recovery.

J. H. CURLE.

London, July 20, 1904

THE PERSONAL EQUATION

(Editorial, August 18, 1904)

THE repeated insistence in these columns on the importance to the mining industry of the sense of professional responsibility among the chiefs who direct the operations of mines, mills and smelters, will have failed utterly if it has not brought out the great underlying fact that personal character is the pilot who steers an undeviating course amid the shoals of pliant circumstance. Character means that a man will do the same thing even under differing conditions; he is wanting in individuality who modifies his action according to temper and environment. It is the one element which gives each man an identity among his fellows. Each is a law unto himself if he possesses character; but a concrete mob, if he does not.

Given the same data, the conclusions formed by different engineers will vary, by reason of the introduction of that decisive element which represents the personality of the man who weighs them, balances them, and decides their relative bearing upon the work in hand. The personal equation is the application of character to practice. While the equation includes an unknown term, that term is supposed to have a fixed value; otherwise it makes a sum too difficult for the business of life, which has no time for complexities. The expression of the personal equation is judgment, that indefinable quality of mind which enables a man to focus the experience of a lifetime upon the work in hand and gives advice which, in all human probability, represents the best solution of the problem set before him. In this effort, training is a factor, in selecting the experience which throws the best light on each separate case, and in establishing the logical bearing of various kinds of knowledge upon the special circumstances to be studied.

When two or more individuals co-operate, various personal equations of unlike terms are combined and the result can no longer be expressed definitely. Character is obliterated, a crystalline individual becomes an amorphous aggregate. You cannot syndicate character.

ORE-RESERVES

(August 18, 1904)

The Editor:

SIR—I may be pardoned for returning to the charge, as the matter has proved of some interest.

In the JOURNAL of April 21, Mr. Lawrence seems to object to the use of the word "amortization," and before his onslaught I hasten to entrench myself behind precedent. My assistant, at my request, has scanned the pages of two well-known standard works on mining, and finds that the word "amortization" appears in those pages no less than 162 times. As to the exact meaning of the word, "Investor," in your issue of June 2,[1] has truly explained the origin of the word and its most proper use. I do not wish, however, to be taken as claiming amortization as a common feature of mining finance. Amortization, as used here, is a factor necessary to consider in financial calculations, yet it is a thing not often actually set out of dividends. In other words, the recovery of capital from a wasting enterprise within a given period is a necessary factor in the calculation of the pros and cons of that enterprise. Having served for the purpose of calculation, it is quite immaterial whether the $2 received from this enterprise should be separated and each stamped individually—one as amortization and the other as dividend—or not.

In the JOURNAL of March 31, Mr. Spilsbury says: "In the first place, from my own experience, I can safely say that the ore-treatment plant, whether milling, concentrating, smelting, or other reduction means, of over 75 per cent of the mines I have known, is from initial erection well in excess of the output of the mine under all ordinary conditions of development." I sympathize most deeply with Mr. Spilsbury that in 75 per cent of his experience and practice his lot has been cast among mismanaged mines. I carefully excluded this class in founding my argument, and I cannot accept the above statement as any refuta-

[1] See article "Amortization," by F. Hobart, p 194.

tion of my generalization. Mr. Spilsbury gives an example of a mine which, I observe, has the following characteristics

1. Under ordinary conditions of development, it returns a fair profit and an "amortization fund of 5 per cent"

2. With mine development of a vigor which I propose, I observe that the hauling engine will not handle the waste dirt, and that the profits will all be eaten up by doing this increased development.

3. I observe that, given this development done, the mine is not likely, with its primary plant, to earn enough profit to build the secondary plant.

4. Supposing that the secondary plant be built, the profit derived from the combined plants will possibly be less than it would from the primary plant.

The case seems to me absolutely hopeless. I must again extend my sympathy to Mr. Spilsbury in having a mine of such truly wretched character, in that the margin of profit is too narrow to stand such a campaign, and that dispersion of the orebodies seems so great, and the waste dirt is of such enormous proportions, that neither the excavations for ore give room enough to stow it away, nor is the hauling engine good enough to cope with it. It is a most trying case, and I feel like admitting at once that this instance is like those emanations of the human brain called nightmares, entirely out of the reach of sound logic. My heart especially goes out to Mr. Spilsbury when I notice that in this particular instance an amortization fund of 5 per cent is considered sufficient, and therefore that the life of this wretched mine is bound to be at least 16 years. If Mr. Spilsbury, however, will give us the figures as to the size of the orebodies, the distance between them, the profit per ton, the total working costs and the fixed charges, I will agree to try to make my plan fit or show that hopes of amortization before death should be abandoned.

For Mr. Ingalls' letter in the JOURNAL of May 5, and Mr. Brown's letter of May 26, I have to thank both Mr. Ingalls and Mr. Brown for the kindly trouble they have taken to understand the points which I desired to make clear and the support they have given. I bow to Mr Ingalls' suggestion that in such metal mines as have a product of variable price the question may, in certain conditions, be very much modified. Mr.

Brown has prepared a useful table, which I trust Mr. Spilsbury will avail himself of, as it very much simplifies the application of the matter and might assist him in his troublous practice.

As to Mr. Brown's suggestion of the temptation of superintendents to treat rock rendered profitable by the lowering of costs, due to increased equipment, and thus lowering the average profit of the mine, so as to even lower the total profit and to upset the calculations on which the extended plant was authorized, I believe Mr. Brown should carry his argument somewhat further —although, aside from the immediate question, I might observe that superintendents should not yield to the temptation to do wrong If there exists in a mine such an amount of ore of a lower grade which can be profitably worked by a reduction of costs, to be secured by larger equipment, as will affect the total output, then this ore forms a problem by itself, entirely aside from the ore which was within the scope of the primary plant. Either this secondary ore warrants an increase in equipment to work it, upon its merits alone, or it does not. If it does so warrant, and the primary ore also warrants an extension of plant for reasons set out in my programme, then there should be two extensions of the plant and not one.

In your issue of April 21, you, in effect, say that the unashamed and essential American idea is that it is poor business to mine for posterity, and I assume from the context that you offer this as a criticism on my plan. The proposal I have laid down will, if followed, exhaust a mine far more quickly than is common in American practice. It is my belief that it is possible to extend the development in the average mine by the depth to which the shaft can be sunk, say 350 to 450 ft. per annum, and if my plan were followed, mines would be exhausted with this rapidity. Instead of most of the American mines being more than 10 years old and few of them excavated to a depth of 1,500 ft., they would, had my plan been followed, have been excavated to a depth of over 3,000 ft ; in fact, among the most serious objections which I see to the proposal which I have made, is not that it works the mines too slowly, but that it works them too fast. It has been suggested to me that from the broad standpoint of public good it will exhaust the mines too rapidly. As Mr. Ingalls points out in—say, copper mines—this programme would flood the market with metal.

In your issue of April 21 you raise the question of the occasional desire on the part of a mine-owner to devote himself to development work with a view to increasing his ore-reserves and profit in sight to a figure desirable from the standpoint of sale of the mine. This, of course, is a matter of policy entirely outside the discussion of a method to get the greatest ultimate profit on the ore itself—this involves the great science of getting the most money out of some other human being.

In your issue of June 23, Mr. Bancroft raises an important subject in a discussion of the care and nurture of infant mines. I wholly agree that the problems which surround the installation of the primary plant may often be far different from those of the secondary plant. Mr. Bancroft's article I must point out to one critic as my justification for stating the case in the manner in which I did—that the real problem of ratio lies for its solution in expansion, not in original installation.

If I were going to generalize on the subject of primary plants I should probably fall back upon the principle of a friend whose occupation is the operation of mines through their nursery stages; that is, "In common business prudence do not erect a treatment plant at all until there is enough profit in sight to repay the cost of it."

H. C. Hoover.

Johannesburg, July 15, 1904.

NO-LIABILITY COMPANIES

(September 8, 1904)

The Editor

SIR—In your discussion on mining finance it may not be out of place to consider the question of the "no-liability" company as practiced in Australia. This system is not well known in the United States, and as it is resorted to so largely in a country whose gold output was last year the largest in the world, it is certainly worthy of consideration. The reason that the "no-liability" company has such a popularity in Australia is that, exclusive of Western Australia, the mines are opened and supported almost entirely by local capital, the shares being held mostly in small blocks. Nearly all miners, and a large proportion of the outside public, speculate in mining shares. Local capitalists not being strong enough to underwrite or finance large undertakings, and with a desire to retain the control of the mines in the country, the "no-liability" company has sprung into existence, until to-day it is an inseparable feature of Australian mining practice.

Previous to the introduction of this class of organization the limited-liability company was the method of flotation adopted; but including, as it did, among its shareholders a great number of miners and others with limited means, when a large "call" was made at one time, the poorer shareholders would often be unable to meet it, and cases have occurred where individuals have been thrown into bankruptcy on account of their share liability. In contrast to this, in a liability company, a person buying shares on which only a fraction of the nominal value has been called up, assumes no liability to meet any future calls. He can drop out any time he sees fit, and in the case of non-payment, usually after the lapse of one month, the shares are sold at auction on the Stock Exchange, after notice of the sale has been duly advertised in the local papers. The no-liability company has been the means of producing a large amount of gold, but it has many

weak points, among the chief of which is the fact that it increases the speculative element in mining investment, and it is the earnest desire of every engineer to reduce the speculative element in mining as much as possible.

One writer would have 80 per cent of the share value of a mine in sight as profit before considering it a good investment. and though that is a consummation devoutly to be wished, yet from the engineer's viewpoint it is manifestly asking too much. This method would require only a sampler and an assayer to determine the value of a mine, but every day the examining engineer is called upon to pass judgment on propositions that could not comply with the 80 per cent condition.

Every proposition we investigate is not a big one, and to condemn wholesale all prospects we come across would require very little of what we may call mining intuition. By prospects as here used, I include properties from which a considerable amount of ore may have been taken, but which have little or no ore in sight. This, then, brings in the legitimate element of speculation, which aspect the engineer can never separate from mining, and with which he must always reckon. In many cases this is quite large enough, without endangering the success of the enterprise by forming a no-liability company, often with an entirely inadequate capital; the amounts secured by each separate call being so small that economical methods cannot be adopted, as the funds do not allow of any scope in planning the work. I do not for a moment mean to imply that all no-liability companies are crippled through this sort of policy, because such is not the case; but a great deal of this hand-to-mouth policy does exist.

The philosophy, then, of the call system is based on the very thing the engineer seeks to eliminate, namely, the element of speculation. A company is formed to work a property. Let us follow the method pursued by a small one of, say, £10,000 nominal capital and £1 shares. One or two shillings may be required with the subscription, and then 3d. per month per share is called; this brings in £125 per month. All work will be carried out in the most slipshod manner, to make the money go as far as possible at the particular moment, with the hope that the mine will soon be able to pay its way. It is true, many people have put money into mines on this sort of a basis who would

not on any other, miners making £2 per week owning and paying calls on small blocks of shares These small holdings, no doubt, aggregate considerable sums and constitute an important percentage of the total capital invested in mines in this part of the world, and, too, they materially support the industry, yet with a proper working capital in the beginning at the disposal of a competent man, a great deal more could be done with the same cash, and therefore with the greater chance of success.

Another great objection to the no-liability company is the ease with which it lends itself to the ends of the dishonest company promoter. In the limited-liability company the larger sums required are apt to cause a closer investigation into the merits of a property, whereas in the no-liability company, as the payments are intermittent, smaller and not as much felt by the investor, he is willing to take a bigger risk, because, he argues, he can drop out at any time, and he often goes into a company much as he would put up money on a horse race. Once in, glowing reports from the mine keep him paying calls, until often he has a considerable sum invested, and then continues, because he has already so much at stake. Taking advantage of this weakness of human nature, the dishonest promoter gets one or more exceedingly favorable reports from a certain class of mining quack and, with these as a basis, he solicits subscriptions. The owner is to be paid, perhaps, a certain amount of cash, in case of flotation; the promoter reserves for himself a sufficient number of shares, issued as fully paid, and the rest are offered to the public. Naturally, attempts are made to create an artificial value in the shares, by issuing glowing reports from the mine, and by whatever other means are at hand. Once a demand for shares is created, out goes the promoter, although, as his shares are fully paid up, he may find it to his advantage to hold on for a considerable length of time, as the more money paid in calls, other things being equal, the more valuable his own holdings become.

Despite all its handicaps, the no-liability company continues, and will continue, to exist in Australia, as it affords the working miner and small capitalist an opportunity of making a stake, and in many other ways suits the conditions of the country. It must be borne in mind that, to a very large extent, the ores are free-

milling, and can be treated in comparatively inexpensive plants, so that, as soon as the pay-shoot is encountered, the property can begin to pay its way without the necessity of having to plan a special metallurgical plant.

C. S HERZIG

Melbourne, July 25, 1904.

ENGINEERS' ESTIMATES OF COSTS

By W. R. Ingalls

(September 22, 1904)

Mr. Whinery, in an able paper in a recent issue of *The Engineering News,* discusses the prevalent distrust of engineering estimates; he admits this distrust to be not without excuse, unless the estimates are reliable. He therefore analyzes the causes that seem to discredit the more carefully prepared estimates. Into every complete estimate of the probable cost of a projected engineering work the following elements enter: 1, Quantity and character of work to be done; 2, physical conditions under which it must be performed; 3, best method of execution; 4, unit cost of the various items; 5, general expense; 6, market fluctuations; 7, ability and skill of execution; 8, integrity and honesty in execution; 9, fortuitous incidents; 10, assumption that plan and scope of work will not be altered. Mr. Whinery considers that only items 1 to 5 are properly within the scope of the engineer, and argues that he is no better able to foresee the contingencies that may arise under items 6 to 10 than the man of business, and therefore should disclaim responsibility for prophecy concerning them. All of this should be distinctly understood, however, and a statement to accompany an estimate, something like the following, is therefore proposed:

"The surveys and examinations for the proposed improvement have been made with unusual care and thoroughness, and plans and outline specifications have been worked out and considered, with great care; the quantities and the character of the work involved have been ascertained as fully as is practicable before the work is actually under construction, and we have made liberal allowance, where any uncertainty exists in this respect. In estimating the probable cost of the work we have based our figures upon the present market value of materials and labor

in the region where the work is to be done. The unit prices applied to the several kinds of work are based upon our personal knowledge and experience, supplemented by all the information we have been able to obtain about the cost of similar work, the special physical conditions that are likely to be encountered in this particular work having been given full consideration. Under the head of general expenses we have added such sums for engineering superintendence, clerical work, and interest and depreciation upon plant as in our opinion should fully cover these items of cost. The estimate assumes that the work will be conducted with the average skill and efficiency. It makes no allowance for possible changes in the plan or scope of the improvement we have outlined, nor for changes in the market value of material and labor. No allowance is made in the estimate for possible improper or dishonest administration, nor for casualties and contingencies which cannot now be foreseen, but which, judging from our experience on work of similar character, should not exceed — per cent upon the total we have reported"

I do not agree with Mr. Whinery that the engineer is no better able to forecast the uncertain contingencies than the lawyer, financier or man of business. He should know better than they as to the ranges in the prices of the labor and material that he has to do with, better as to the limits, ability and skill in the execution of this kind of work, better as to the general nature of the fortuitous accidents that may happen and the ways of guarding against them, and better as to the probable losses through dishonesty, because all of that is part of the experience that he has gained in the execution of similar work. If he has not done similar work he cannot be expected to make a trustworthy estimate; but if he has, he is naturally better able to forecast the chances than the lawyer, financier or man of business who has had no such experience at all. In other words, the modern engineer in order to be successful must necessarily be a man of business himself; and the only ground for placing confidence in the estimate of a business man in engineering matters is when he is something of an engineer himself, which in fact many modern business men are. I think that no blame will be attached either to the engineer or business man for a cost in excess of estimate which is due to a defalcation of funds, or a change in the plan and scope of the work after the estimate was made,

although the engineer may even foresee the possible advisability, or necessity, for making certain changes from the original plans and can also estimate in advance their probable cost.

I think that Mr. Whinery rather hedged from his original position when he presented his proposed explanatory note to accompany an estimate, which is in my opinion fairly well expressed, except it does not go quite far enough, because the engineers can say:

"We have based our figures upon the present market value of materials and labor in the region where the work is to be done. These values are — per cent above (or below) the average of the previous 5 (or 10) years. The general trend of the market has recently been upward (or downward). The proportion of labor in the total estimate of cost is — per cent, of materials, — per cent, etc."

One of the questions that is frequently asked the engineer is, What would be the effect of a reduction in the prices for labor and material? Plans and estimates for a certain work have been prepared. The work has been deferred. A year later, the engineer is asked what will be the cost of the work then. A large work, to run through a series of years, is to be undertaken The prices for labor and material are bound to change during that period. At the beginning they may be at the lowest on record, close to bed-rock, with every prospect of an upward trend in the markets. The engineer should know this; it is his business to know it; and if he bases an estimate on the minimum prices he is as much to blame as if he were at error in his quantities.

Mr. Whinery's suggestion to distinguish clearly between the more and the less certain parts of an estimate is praiseworthy. It is analogous to the discrimination of "positive ore," "probable ore" and "possible ore" by the engineer valuing a mine. Either in estimating the cost of a works or the value of a mine, it is the engineer's business to express an expert opinion, and in rendering only a partial opinion, leaving someone else to draw the final conclusion in order to shield himself from responsibility, he is derelict in his duty. A deliberate overestimate is as reprehensible as an underestimate. The commercial purpose of an engineer's estimate is not merely to indicate how much money is going to be required, but also to serve as a basis for calculation of the probable return on the money.

There are plenty of engineers in practice who are able to estimate closely what work will actually cost, as proved by experience. They command large fees, and properly, for their work involves technical and business knowledge of the highest order. The financier should see that he gets this kind of engineer, and when he is sure that he has, he should be careful not to obtrude his own less expert knowledge. Fair industrial projects are not infrequently rejected as not good enough, because a sound engineering estimate of cost is increased 25 per cent, 33 1-3 per cent, or more "on general principles" by the business man whose previous experience has been gained at the expense of defective engineering advice.

GOLD DREDGING IN CALIFORNIA

By Chas. G. Yale

(September 15, 1904)

The following data relative to costs of a dredge operating at Oroville, Cal., are the averages covering three years' work, and are taken from the books of a company.

Size of buckets, 5 cu. ft.; average speed of buckets, 12 per minute; average bank measure per month, 46,032 cu yd.; average hours running per month, 535; average kw. hours per month, 23,-995; average cost of power per month, $359.93; average cost of oil, grease and sundries, $13 29; average cost of repairs, $1,212.09; average office and general expenses, $177.40, average labor cost, $496.33; average depth of ground, 26 ft.; age of dredge, 3 years; average total cost of operating, 4 88c. per cu. yd.

Taking the average of the Oroville ground at 16c. per cu. yd. and writing off 10 per cent for deterioration of the dredge, will leave a net of 14.4c. per cu. yd. Deducting cost of operation of 4.88c. leaves a net profit of 9.52c. per cu. yd. on all the property cited, and a net profit of $52,587 per annum, or over 30 per cent interest on the capital invested.

Probably the best showing that can be made as to low costs is in another instance at Oroville, where a monthly statement shows that 50,760 cu. yd. were dredged, or an average of 1,692 cu. yd. for each working day, at a total cost, with all expenses, of 3.66c. per cu. yd. The average yield of the ground per cu. yd. was 18.9c., and the net profit for the month was $7,744. This was done with a 5-ft. continuous bucket dredge

GOLD DREDGING

(October 6, 1904)

The Editor

SIR—In your issue of September 15 we note an editorial giving costs of gold dredging at Oroville. Having recently had occasion to investigate this matter, we take the liberty of questioning the accuracy of the figures given.

The cost per yard, 4.88c., is below the general experience of this district. Seven cents per yard would be much nearer the actual operating expense of the 5-ft. dredges now in use. The last company to invade this field, guided by the previous results obtained, has allowed 8c. per yard to cover operating expense and depreciation, the latter item being estimated at about 1c. per yard.

The statement of 23,995 kw. hours per month is less than half of any figures that have heretofore come to light. Labor at $496 per month is also much below the best results so far obtained. There are several instances where dredges have been operated for a month or more at a cost of less than 4c. per yard, but estimates of costs, yardage, etc., from periods of one month are entirely misleading. Repair expenses range from one-quarter to one-half the total cost of operations, and for many months they may be comparatively small. This, of course, will give a large yardage and low monthly expense. Consequently the cost per yard will be much below the normal On the other hand, a month when much repairing and renewal of dredge parts took place will give a low yardage and a high monthly operating expense, giving costs per yard much above the average.

One dredge at Oroville ran continuously for eight months, making a splendid record, and then shut down 39 days for repairs. The fact, therefore, is obvious that costs per yard are reliable only when periods of a year or more are considered.

The present tendency is to increase the size of the buckets and the strength of the wearing parts. This increases the yard-

age, with practically the same labor charge, and a less than proportional increase in the expense for power and repairs. It is expected that the improved dredges capable of handling 80,000 cu. yd. and upward per month will reduce the costs to 5c., and lower, per yard, but this cannot be done with dredges having a capacity of only 46,000 yards per month.

Yours respectfully,

STEBBINS & SMITH.

San Francisco, September 22, 1904.

[This criticism is made fairly and with some reason. We can quote average costs and yield for a well-known dredging company at Oroville, which has been in operation for 5 years. The average cost for each year has ranged between 4.92c. and 7.47c., averaging 6c. for the whole period; the yield has averaged 13c. per yard.—EDITOR.]

MINING IN MISSOURI

(November 3, 1904)

The Editor.

SIR—In Missouri there are two important mining districts. The Joplin district, in the southwest, is the largest producer of zinc in the United States. The mines of St. Francois county, in the southeast, rank that district as the second largest producer of lead. The Joplin district is also a considerable producer of lead from ore concentrated, as a by-product, in the milling of the zinc ore. Such comparisons as are to be made in this letter are not for the purpose of pointing out the relative merits of the two districts as fields for mining operations, but merely to show in a striking way the baneful results of the labor union policy as applied to mining. Everyone knows what the results have been in Colorado, but—fortunately, lacking the gloomy record of outrage and bloodshed—Missouri presents the more instructive industrial picture of "before and after," which it can show contemporaneously.

The ore mined at Joplin yields on the average about 4.5 per cent of blende, worth, say, $35 per ton, under the normal conditions of the present time, and 0.5 per cent galena, worth, say, $50, or an aggregate of 5 per cent of mineral worth about $36.50. The ore mined at Bonne Terre and Flat River yields about 5 per cent of galena, worth about $37.25 per ton f.o b. mines, when lead is at 4c. St. Louis. At Joplin there is great and general prosperity In St. Francois county the mining companies are struggling along at little or no profit, hoping vainly for an amelioration in the conditions. It is strange that ore of the same grade and value can be worked profitably at one place and cannot be worked profitably at another place in the same State, especially when the physical conditions are all apparently in favor of the unprofitable mines.

At Joplin there are comparatively small lenses of ore and sheet deposits, averaging only about 8 ft. in thickness, the min-

eralized ground being the hardest kind of chert. The mines are worked in a crude kind of way, opened by small shafts, hoisting ore in small tubs by means of uneconomical engines, and dressing the ore in ramshackle mills of comparatively small capacity, the entire cost of opening a mine and equipping it with plant to treat 10 tons per hour being only about $15,000. At Bonne Terre and Flat River there are immense shoots of ore, affording stopes of 20 ft to 80 ft. in height, and width almost to suit; the ore an easily mined dolomite, ground of character requiring no timbering, depth of mines only slightly greater than at Joplin, and no greater influx of water, except in two or three instances, the mines opened by fine large shafts, equipped with nearly the most modern facilities, the ore dressed in complete and costly mills of 500 to 1,500 tons daily capacity. Surely St. Francois county has all the advantages of physical condition, and theoretically ought to surpass Joplin in operating costs. The explanation of why it does not, involves some technical factors, but the chief cause is to be found in the character of the miners and their work.

The mines of St. Francois county used to make money. The minimum price of lead in the history of that metal did not stop them, and they have shown good profits when lead was considerably less than 4c. per lb. This, however, was before the labor union was organized in the district.

The mines of St. Francois county are operated by large companies. The cost of opening and equipping a mine there is so large that a company with abundant capital is required. For that reason there is no leasing nor any individual operations. The condition of the miners was good; they were paid high wages, as compared with the scale for other trades in that part of the country; the day's work of 10 hours was no longer than was required of other artisans; the mines were sanitary and in no way especially dangerous; the men were well cared for by the companies. The entire mining district is pleasantly situated, far more pleasantly than the average. The climate is good; all the conditions of living are good. The men were well satisfied, and a general air of prosperity pervaded the entire district. This was before the diseases of unionism and socialism were contracted.

In the struggle which ensued, the unions were victorious. The companies made no fight in line, shoulder to shoulder. Some of them made no fight at all, and surrendered without a shot.

The others fought alone, one by one, and were overwhelmed one after the other The unions won an increase in wages, a reduction in working time to 8 hours per day, and the victor's right to despise the conquered, which in successful labor wars takes the form of cheating the employer in the work that he pays for The amount of work done per hour at Flat River is materially less than before the advent of the union This is the chief reason why the mines of southeastern Missouri are not making money.

Joplin has never been tainted with unionism. It has always been the great camp of the small miner. The capital required to open and operate a mine there is not large, and the operators themselves to a large extent take hold and work with their men. Every hired man wears on his head the hat of a future operator. He saves his money, and sooner or later does some prospecting on his own account. If he is lucky, good for him. If he is unlucky, he goes back to work until he can save enough to try it again. Everybody works hard—works hard every minute of the day—and when the day's work is done he seeks enjoyment in such way as most appeals to him. The general aspect of things at Joplin and Flat River shows at first sight that the Joplin man has the more fun. The man who has done a good square day's work is better calculated to enjoy himself, anyway, than the man who has listlessly loafed through his task. And the Joplin men certainly work. A pair of men break more to the drill in their hard, flinty ground, with no very high breasts to stope on, than the Flat River man breaks in his magnificent chambers in limestone; and when it comes to shoveling and tramming, there is no comparison at all. Nor has the former any kind company to provide him with lavatories and lockers, look out for his safety, and pay him damages for unavoidable accidents. The Joplin man simply takes his chances—often they are big chances—puts in an honest day's work, and gets on in the world if there is anything in him at all. But Joplin has no union. Joplin has the best American spirit, and, consequently, Joplin is prosperous, and can mine 5 per cent ore with little tubs and ramshackle mills, and make money; while the far greater deposits of an equally valuable ore in St. Francois county cannot be made to pay a reasonable return on the capital required to work them.

W. R. INGALLS.

New York, October 18, 1904.

SECRET RESERVES

(Editorial, November 24, 1904)

LONDON and Kalgoorlie are perturbed at the present time over the right and wrong of a practice which in different forms is familiar to mine managers elsewhere; we refer to the maintenance of a reserve intended to equalize a variable output This question was discussed in our issue of May 12, 1904, by Mr. F. H Bathurst, of the Melbourne *Argus*; but that well-known authority on mining matters dealt with the problem in its more local aspects, as exemplified by companies operating in Victoria. However, the principle involved is the same. The importance of it from a financial standpoint has been emphasized by the Boulder Perseverance fiasco, an inquiry into which has elicited the fact that a reserve of 20,000 oz. of gold—say, $400,000—was held at the mine; from this store of unreported bullion, it was the custom to take three or four thousand ounces at a time in order to increase the monthly returns when these fell off. In 1903 the actual output of the mine was 209,206 oz., but the output declared was 219,923 oz. In January, 1904, the actual output was 12,426 oz.; but 17,471 oz. was stated to be the production of the mine for that month In the first three months the secret reserve of bullion was depleted to the extent of 10,000 oz. During the first six months of the current year it became manifest that the mine could not maintain a rate of output based upon a certain estimate of ore reserves; but the gradual falling off was obscured by doctoring the returns in the manner described until finally, the secret reserve being exhausted, the facts had to come out, and there was a collapse, as injurious to the professional men connected with the management as it was distressing to shareholders who had bought stock at a price based upon a fictitious production. In the course of an official inquiry, the statement was made that the Oroya-Brownhill, a great gold mine, thoroughly well managed, gave out monthly returns so uniform in their amount that the services of

a secret reserve were manifest. It was also stated that this practice was usual in Western Australia.

Before proceeding further, let it be emphasized that Western Australia is not the one corrupt spot in the mining world; it has had several unsavory scandals, and it has been the victim of a number of unscrupulous campaigns, waged both on the bear and the bull side of the market. This is due not to any inherent Westralian depravity, but, as is obvious to men of experience, to the unusual richness of the orebodies, a richness which in nature is concomitant with irregularity of occurrence. As against these troubles, so hurtful to the advance of mining as a legitimate business, must be placed a big credit for honest management, technical skill and unremitting energy, on the part of a handful of technical men, both English and American, without whom the Westralian mining companies would have been in a bad way indeed. In brief, human nature being the same the world over, mines characterized by rich and erratic orebodies afford the maximum of temptation to wrong-doing.

A fluctuating output and a secret reserve represent a state of equilibrium comparable to a powder magazine enclosing a small boy armed with fireworks. We are aware that the gold is not necessarily held in a vault; it is the custom to realize upon it and to carry a balance at the bank, transfers from which effect the purpose of regulating the returns as reported; but even though burglary of bullion is not involved, a theft no less vital is always on the cards—the loss of one man's reputation or another's property as expressed in share values Take the case in point; the absentee manager of the Boulder Perseverance has had to suffer from statements of output which—explain it as you will—were false. To go further, the management of the Oroya-Brownhill is, we believe, operating that mine with a view to serving existing shareholders; and if a reserve is kept, it is for the purpose of avoiding such fluctuations as render shareholders anxious It is more than likely, however, that in this case the possession of certain stopes of extraordinary richness renders it unnecessary to store bullion in the safe or to carry a corresponding balance at the banker's. In any case, a remedy for variation in the yield can be secured by methods less dangerous. In these company matters, publicity is the best preventative of wrong; secrecy is its incubator. State your output, whatever it may be, if you have a block of

ground unusually rich, say so, if you carry a reserve of bullion, state that fact; publish the amount of special ore which may have been stoped during the month or the quantity of bullion transferred from the reserve in order to sweeten the returns. In short, have your reserve, but get rid of secrecy; maintain a steady output, but state how it is done. If not, cease monthly reports, which disturb timid shareholders by reason of their fluctuation, and issue half-yearly reports with interim records of progress. Surely silence is better than falsehood. A policy of straightforward frankness, accompanied by the fullest publicity, is the only cure for the present condition of affairs at Kalgoorlie; it is as necessary as fresh air to an invalid

EQUIPMENT AND ORE-RESERVES—VI

(Editorial, December 1, 1904)

THE discussion on the proper ratio between mine equipment and ore-reserves is taken up again in this issue by an engineer whose experience gives special value to his observations. Previous contributions on this subject have brought out two points of view, which, naturally enough, are held to represent the opposite standpoints of financial surety and practical mining; the one asks for the maximum security consistent with a reasonable rate of interest; the other demands the largest gain in the least time. Mr. Curle's now famous requirement of a 60-per-cent reserve represents the investment view; while Mr. Hoover's insistence on the increment of profit due to rapidity of extraction expresses the intention to get the largest amount of money out of a given body of ore As a matter of fact, any discussion of these differences of opinion will continue to be at cross purposes until it is realized that only one form of ownership is contemplated, namely, that of a limited liability company, organized and conducted under certain recognized conditions. If the mine is owned by an individual who has no intention of selling it, the problem is simplified; there is no share quotation to maintain, no diversity of interests to please, no directors to educate, and no financial press to consider. It becomes simply a question of logical method, striving to make the most money out of the ore deposit; the aim will be to avoid the wastefulness of an extraction so slow as to allow ore-reserves to remain underground unrealized, while fixed charges consume small profits, or the extravagance of an exploitation under which the increment of profit due to rapidity of extraction becomes overwhelmed by the interest to be paid on an equipment the services of which are soon ended by the exhaustion of the mine. The fact is, we do not quite appreciate how greatly our methods are dominated by the fluctuating ownership of mines; shareholders form a dissolving body of proprietors the interests of whom are divergent

according as they have bought as investors, to hold indefinitely, or as speculators, to sell on the next rise.

To the investor, ore-reserves are an insurance; and, even though the opening up of an excessive area of ore-bearing ground represents the expenditure of capital not immediately remunerative, he feels that the added expense is worth the additional security. The speculator buys to hold for a time, until he has a reasonable profit, but in any event he does not contemplate retaining his holding until the bitter end—when the mine is worked out. To him completeness of equipment with capacity to extract rapidly, at least as rapidly as the opening up of new ground, affords the results most to his liking—a rising quotation, an increased dividend, and a proximate disposal of his holding at an enhanced price.

We can illustrate this view of the matter by quoting the case of a company which carries a year's output in the shape of broken ore; apart from reserves in the form of blocks of ground not yet mined, there is this big tonnage of ore already mined lying in the stopes From the investor's standpoint—Mr. Curle's—this is insurance of the best kind; for obviously ore actually stoped, sampled, and assayed can be appraised with an accuracy not possible when it is in place in the lode. As the speculating shareholder sees it — as Mr. Hoover would regard it — this is just so much money lying idle underground, on which not only is there no interest forthcoming, but it requires a constant, though small, expenditure in the way of maintenance—that is, timbering, ladderways, tracks, etc. It is here that we disagree with Mr. Curle—sound as his views are on most matters of mining finance. We consider that mining cannot be safeguarded to the extent of eliminating risk; or, rather, we repudiate the idea that by demanding a certain ratio of ore-reserves and a specified rate of dividend, you can make a mining investment as safe as a railroad bond. By vigorous development, by accumulating broken ore, and by enlarging the bins, you decrease the uncertainty; but the risk remains —it is the essence of mining. Therefore, the increased equipment and the faster extraction—with the concurrent advance of development, a larger dividend and a smaller ore-reserve—represent the soundest kind of mining. Under company management, that rate of extraction in which, as Mr. Hoover claims, the increment of profit due to enlarged equipment balances the amortization of the additional capital invested in the equipment, gives the fluctuating

ownership the best return. If this is accompanied by accurate periodical estimates of reserves, by a frank and frequent record of progress, and by a management which does not buy or sell the shares of the mine under its direction, there is achieved the most profitable form of business known to the modern world

SECRET RESERVES

(December 1, 1904)

In regard to this matter, which was discussed in our editorial columns last week, it is interesting to note the views of four leading mine managers at Kalgoorlie, as elicited by a Royal Commission which is probing the Boulder Perseverance scandal

In course of his evidence, Mr. Richard Hamilton, manager of the Great Boulder Proprietary, deposed on oath: "It is the custom of most of the mines here to have a bullion reserve. I think it is very advisable to have one to keep the returns even; it prevents fluctuations in the market, and enables you to work the mine cheaper. If you had to keep the returns even by taking the ore out of the mine, you would not be able to do straightforward stoping. The amount of the bullion reserve should depend upon the character of the mine, but half a month's return would be a fair thing. Our reserve is kept locally. If you did not keep a reserve you might have a 25 per cent or 30 per cent variation; such a fluctuation would affect the market probably to the detriment of the shareholders. I am in favor of limiting the reserve to half the month's output. The bullion reserve does not show in the yearly balance-sheet in every case; the control of the bullion reserve is generally left to the manager I have not had any definite instructions to keep up a normal output. The directors do not always know of the bullion reserve. The Chamber of Mines has recommended that bullion reserves be kept, but with no limitations as to the amount. I am in favor of giving every opportunity to shareholders of acquiring information about the mines; I would not let them know what the bullion reserve was. I think developments should be announced here simultaneously with London; I would also give publicity to the assay plans, and would withhold nothing but the bullion reserve. I do not see that it is necessary to have local directors; those who subscribe the capital naturally want control of the mine. There does not seem to be a very large

body of investors in Western Australia; Westralia would derive greater benefit by having the mine offices where the capital is available. I do not think you require any more legislation than you have at present to prevent mining scandals; Royal commissions, such as the present, would act as a greater deterrent than in enacting fresh legislation." Mr. Hamilton gave a description of his sampling methods, saying he generally took samples not more than 10 ft. apart.

Mr Robert B. Nicholson, the manager of the Ivanhoe, in the course of his statement, said: "I am in favor of a bullion reserve. In a mine like the Ivanhoe it is quite possible to have a variation of 25 per cent in the output, and that would be detrimental to investing shareholders. In a mine like the Ivanhoe, where we get slides, the fluctuations are considerable. I think 75 per cent of the month's output is a fair thing for a bullion reserve. The directors know exactly what the output is; it is not desirable to let the shareholders know the actual figures. The bullion reserve is merely to regulate the monthly output. Two of the officials on the mine beside myself know what the reserve is. The holding of the reserve makes the costs of mining cheaper; for instance, you would leave a lot of low-grade stuff behind you if you had no bullion reserve to work on." Mr. Nicholson, in describing the sampling practice on his mine, said he took assays every 3 ft., cutting everything above 5 oz. down to that figure in calculating averages He continued: "I think the public generally should have access to the mine. They have access to the Ivanhoe; we will show them the assay plans up to the date they are received in London; we publish all information here simultaneously with London. I do not think it would be wise to legislate that ore-reserves should only be those opened up on three sides; it should be left to the discretion of the manager. What is really wanted is the publishing here of the fortnightly reports, giving widths and values; we do it on the Ivanhoe"

Mr. Frank A. Moss, general manager of the Kalgurli and Hainault, deposed: "The Kalgurli differs from most mines on the field. We have very big lodes, but no definite line of lode, and unless we had a bullion reserve we would have a bad time." (Witness produced a plan showing a stope 190 ft. long and 132 ft. wide, and explained to the Commission that in working such a big orebody it was impossible to maintain an even return.) "In January

our output was 5,800 oz ; probably six months later it would be 2,800 oz. Still, our shares never fluctuate, and that is due to the use of a bullion reserve, a month's bullion reserve is quite sufficient for us to maintain an even output We do not expose ore on three sides in our mine, we go by what we have taken out Supposing we take 20,000 tons out from 20 ft in height, and it goes 17 dwt., we reckon the next 20 ft. should be something the same. No hard-and-fast rule as regards estimating ore-reserves would apply to the Kalgurli We have a stope 65 ft wide at 640 ft, and at 700 ft it is 5 ft wide; 80 ft. south of that it is 80 ft wide at the 700 ft. My estimates, so far, have worked out correctly If any persons wanted to sample the Kalgurli it would take them 12 months; they would have to shoot the stopes out to do it In the Kalgurli I would not take samples even in 5-ft. sections; for instance, in one face we may be on 10-dwt. ore, and the next cut might give us 5 oz. My instructions are that the mine plans, assays, etc, are to be open to the public."

Mr. George M. Roberts, manager of the Associated Northern Blocks, deposed: "I think it is essential to have a bullion reserve equal to half the month's output, values in these mines are very erratic; in the event of legislation I would say a month's reserve. There are about 200 ft. of country in our mine, ore-bearing, carrying lenses of ore; face samples are very misleading in our case, and it is a difficult mine to reckon up the ore-reserves. I would not make even a preliminary report on samples taken 50 ft. apart; it would be useless. I would like to sample at least every 10 ft, and then compare my results with the mine assays; if I were buying a mine I would sample every 5 ft. I am in favor of a mine being worked openly; our mine has been open to the public ever since I took charge. I consider the keeping of a bullion reserve assists us in cheap mining."

MINE EQUIPMENT AND ORE-RESERVES

(December 1, 1904)

The Editor

SIR—If a few words, rather late in the day, can be granted me, I would like to submit a consideration of the difference between the policy advocated by Mr. Hoover and that urged by Mr Curle. This difference is partly fundamental, and, in part, one of premises. Mr. Hoover says: "It will be granted that the true objective of mining is to gain the greatest profit from a given body of ore." Mr. Curle, using mining as a generic term, embracing finance as well as practical management, answers "that the greatest technical economy is one thing and financial security another, that high-pressure development and the economic limit of reserves, while satisfying the one, are in contravention of basal principles of the other," and further, that capital being the first essential of operations, "those who pay the piper must call the tune."

This assumption of the opposition of practical mining and finance is so much of a facer for those engineers who are trying to reach the most economical basis of operations that it is worth our while to examine the matter with some closeness.

There is no dispute in this case about the economy to be effected by Mr. Hoover's policy of forced development and unit-plant additions. The financial argument against it is that, while increasing profits, it decreases ore-reserves, and tends to keep them at about a three years' limit. The investor looks upon ore-reserves as the security for his investment, and feels that he has little enough of that if he allows two-fifths of his capital (Mr. Curle's ratio) to stand without that security. In other words, under normal conditions of bottom development he asks that for every $100 of stock valuation there should be $60 of actual profit in reserve; then, if the mine be paying 10 per cent on that valuation, there would be six years' dividends assured in the reserves.

The addition of further treatment units may, through the increment of profits, increase the net value of the reserves by 20

per cent and the annual dividends by 100 per cent. The increased dividend rate, moreover, has the effect of raising the stock valuation as well, by perhaps 100 per cent, while the ore-reserves, in point of time, are diminished by half. I think this states the argument fairly.

For the original investors, those who bought on the $100 basis, on which the property was paying its 10 per cent dividend, there seems to be no question that the secondary equipment has been a financial gain, regardless of the increased stock valuation, and it is hard to see what in the condition of the mine should tempt them to sell even at the enhanced price; by so doing they would be sacrificing a high-return investment, and one that actually exceeded the three-fifths profit in ore-reserves, and could scarcely hope to reinvest their increased capital on as good terms as that. This in itself would tend to strengthen the investment view of mines, and weaken the speculative.

It may be granted, however, that some would sell, and the new holders would have a 10 per cent investment, as the original holders had, but through the short life of the mine they might, by failure of subsequent development, lose part of their capital. The question is whether this ought to be considered in deciding on the secondary plant. Should the present stockholders be sacrificed in pocket because of some possible people who may buy the shares later?

Stated in this way, the question implies its answer, and I can see no reason why either the management or the directory, who are expressly chosen by the present stockholders to look after their interests, should have any doubts in the matter. We may all be sorry for excitable and short-sighted investors, and look forward to the time when a clearer view of what constitutes value in a mine will obtain—may even exert ourselves, as Mr. Curle so successfully has done, to bring the time nearer; but this is entirely irrespective of present policy. In short, it seems to me absurd to hesitate about lighting a fire in A's stove because B may burn his fingers at it; rather the clear-seeing economist should argue that some time B must learn all about fires, and the sooner he is scotched the sooner will he become enlightened

Perhaps Mr. Curle would argue the hopelessness of expecting people to sell a share yielding an annual $20 for $100, even though, on Mr. Curle's basis, it lacks security. This may be true, but does

not this simply indicate that the layman does not accept that formula of chances? In the absence of the geological and historical data that would give the best evidence obtainable of the future of the mine, or, perhaps, because of inability to understand them, he believes he can have no safer guide than his experience in other investments, and, according to what that has been, he capitalizes the particular profit. This is not saying that, as an expression of averages, Mr Curle's formula is not sound; we are considering it as applicable to particular cases, and for such, statements of averages are of doubtful value—one cannot predicate a man's height from the mean of the human race

In conclusion, may I be allowed to point out that the term "insurance" is not safely applied to what security may be obtained from large ore-reserves, as distinct from "economic" ones Insurance is a definite security for which a definite premium is paid; in this case, the security is indeterminate and the premium depends upon the increment of profit, which is the sum actually sacrificed for the security by insisting upon the two-thirds rule. This varies from dollars to thousands; but, whatever it may be, it is an unknown quantity unless the investor is awake to the function of "fixed charges" and understands the "increment of profits" When this degree of knowledge has been reached, it is not a far step to a technical view of the real prospects of a mine as distinct from the average view, and knowledge on this point removes the need for the use of the two-thirds rule.

What I have wished particularly to make clear is that the two-thirds rule with its consequences does not tend to a rational treatment of mining investments; that it does not of necessity make for the less speculative view of the industry; that it does not even invite the best class of investors, those who will try to understand the needs of the business.

R. GILMAN BROWN.

Bodie, Cal, November 9, 1904.

GOLD DREDGING AT OROVILLE

By Howard D. Smith and Elwyn W. Stebbins

(December 8, 1904)

The growth of the gold-dredging industry of California has given it a leading place among the mining activities of the State, and there is every indication of a further increase in its importance. The most extensive operations have been carried on at Oroville, where, of the 28 bucket-line dredges so far constructed, 27 are now in successful operation, and the ground upon which one dredge failed to pay profits is at present worked with good results by another company. Several dredges are in process of construction, and active prospecting is increasing the area of proved and profitable dredging ground.

The character of the ground at Oroville is peculiarly favorable to dredge operations. The false bed-rock is comparatively flat and quite soft, being merely a bed of volcanic tuff overlying unprofitable gravel. Few boulders weighing over 500 lb. are encountered. The gravel being rarely compacted, there is no need for blasting; in the present river channel and adjacent thereto the gravel is loose and easily dredged. On some high ground, where the deposit antedates that found nearer the river, it has been found advisable to blast the bank. At the expense of a decreased yardage, the hard gravel can still be dug without blasting; but the high bank, at times 20 ft. above the highest obtainable pond-water-level, makes it advisable to blast, otherwise the undercut bank will cave in large portions, so as to endanger the bucket-line and the dredge itself. For blasting, 30 to 40 holes per acre are drilled, usually only to water-level, each being charged with 100 to 125 lb. of No. 2 dynamite. This increases the yardage handled daily, as well as obviates danger from the caving of the bank. The extra expense of 2.5 to 3c. per yd. proves to be good practice under the circumstances.

The gravel is of a depth suited to dredging, being from 20 to

60 ft., with a comparatively even surface. For a gravel deposit, the gold is evenly distributed, ranging, in large tracts, from 10 to 35c per yd. The whole Oroville district probably averages about 16c. per yd. The gold is all fine, screens with $\frac{3}{8}$-in. holes being used. Winters are mild, and no difficulties from freezing are encountered. Water is conveyed by an excellent ditch system to all parts of the district, the expense averaging about $125 per month per dredge. Unlimited electric power is obtainable at 1.5c. per kw. hour.

An excellent class of labor can be had at the following wages:

CREW FOR ONE DREDGE.

1 Foreman	at $5.00	per day	$5 00
3 Winchmen	" 3 00	"	9 00
3 Oilers	" 2 50	"	7 50
1 Blacksmith	" 3 50	"	3 50
1 Helper	" 2 50	"	2 50
2 Chinamen	" 1 75	"	3.50
Total			$31 00

In addition there is a superintendent, whose time is generally distributed among several dredges. The winchmen and oilers work 8-hour shifts, while the blacksmith and helper work 10 hours. The Chinamen clear the ground of brush and trees, "bury dead men"[1] and do general chores.

Low costs are attainable largely by reason of convenient communication with San Francisco, and the presence of well-equipped machine-shops on the spot.

The ground is prospected by shafts or drill-holes sunk to bed-rock, the gravel therefrom being rocked or panned. Beside giving a sample of the gravel, prospect holes should yield important data, as to the distribution of the gold, the character of the deposit and the nature of the bed-rock.

The gravel from successive lengths of a hole is treated separately, and the respective amounts of gold estimated. Such estimates are checked with the weight of the gold recovered from the entire boring. With practice this estimation becomes fairly accurate. Shafts are preferred where it is possible to sink them, as they give more complete and accurate information; but if water is present in any quantity, they become too expensive, and drilling

[1] Not in the mortuary sense; in dredging, "dead men" are anchors of wood or metal to which mooring cables are attached.

must be resorted to. Owing to the availability of Chinese labor, shafts are cheaper to sink in dry ground than drill-holes

About one hole per 5 or 10 acres will serve to sample a large tract; but prospect holes are put down much more frequently in the immediate vicinity of the dredge, both before construction and during operation. If care is not exercised in prospecting with drilling machines, the sample may easily prove misleading. Errors frequently occur from the squeezing of material into the bottom of the casing, thus giving a larger sample than is called for by the size of the hole. Sliming and consequent loss of gold will sometimes result when too long a period of churning transpires before pumping the hole. The casing should be kept driven below the point of drilling whenever possible. The practice is to drill and pump the hole in 1-ft. sections, the material from each foot being panned separately. Where great care is required, sections of only 6 in. are drilled and pumped at a time. Frequently the whole foot can be pumped with but little drilling. The drill crew consists of one man in charge, one sand-pump man, one drill-man, one fireman and one or two laborers. The man in charge should have a knowledge of the principles of sampling, for upon his judgment depends the value of the results obtained. He usually does the panning himself. Where oil is used for fuel, one man attends to both the sand-pumping and firing. The cost of sampling with churn-drills, under favorable circumstances, is $2 to $2.50, with $3.50 per foot as a maximum.

Gold dredges are similar in general type and operation; but details of design are of great importance. In fact, successful dredge-building depends upon working out the details, and a dredge properly built for one locality, with given conditions, may be totally unfit for another. If a dredge is not suitably constructed for its particular work, the cost of repairs is certain to be large. The importance of this consideration is shown when it is understood that this item of expense ranges from one-quarter to one-half the total cost of operation. Several types have been tried, but the bucket-line dredge has now superseded all others. Buckets with a capacity of 3 cu. ft. were first used; later, dredges were built with 5-ft. buckets, while near Folsom a 7.5-ft. bucket has been used with a fair measure of success, and a new dredge, of the same capacity, correcting the faults of the first, is now in process of construction. Dredges of 11 and 12-ft. bucket capacity

are used in other districts, but it is impossible to compare results without data covering all the local conditions Two 5-ft. bucket dredges, built to handle gravel to a depth of 60 ft below the water level, are now undergoing the severe test of actual operation on the Yuba river.

The advantages of a large bucket are increased yardage with practically the same labor, the possibility of handling bigger boulders, a less than proportional increase of power and general expense, and probably a less than proportional increase in the cost of repairs. The disadvantages are—a greater first cost, the necessity for special facilities for handling the heavy dredge-parts when making repairs or renewals, and the increased difficulty of washing the large and highly irregular amount of material delivered by the buckets to the screen It seems probable that the 7 5-ft., and possibly larger, bucket will prove the most desirable under conditions existing at Oroville.

Gold is lost in several ways. A certain amount goes off in the tailing from the sluices; and, if the gravel is not thoroughly washed, the coarse material will carry some up the stacker Some is left on the bed-rock, though this amount should be small. A slight loss occurs from the material which drains from the buckets into the well during their journey from the bank to the upper tumblers. Exhaustive tests of the table-tailing have been made, showing a very small loss, in no case as much as 2c. per yd. With good management it is probable that an extraction of about 90 per cent is obtained. Both cocoa-matting and angle-iron riffles have proved excellent devices, most of the gold being caught directly under the screens.

While it is not advisable here to go into the subject of dredge-building, it is well to mention one or two points. The bucket-line and tumblers are subject to enormous strain and wear; their maintenance constitutes the larger part of the repairs. Any improvements which increase the strength and life of the various wearing parts, without excessive increase in cost, are sure to be welcomed. The operators have been constantly urging manufacturers to make stronger machines, so that the expense in lost time and in repairs will be diminished. The tendency toward increased strength, power and capacity is still in evidence. The 7.5-ft machine, in process of building at Folsom, has bucket-pins of 6-in. diam., and other parts in proportion. A capacity of 110,000 yd per month is

expected There is a valuable device for increasing the pitch of the tumbler faces to correspond with increased pitch of the bucket-chain links, which results from the wearing of the pins. The revolving screen is desirable for clayey, sticky gravel, as it helps disintegration more than the flat screen; where ground is not sticky, however, the flat screen is preferable, since it costs less, is easier to repair and renew, and uses less power. It is important that the power which drives the bucket-line and that which raises the ladder should come from different motors. There is thus reserve power in case the bank caves, so as to cover the ladder and buckets When dredging an overburden of barren soil, some convenient method of disposing of it, without passing it over the tables and fouling the riffles, is desirable. For this, and other purposes, the hopper should be made to discharge into the well, or to one side of the dredge, when desired.

Both intermittent and close-connected bucket-lines are in use, but the close-connected type, as a rule, finds more favor among operators. It is claimed—and it is undoubtedly true—that the intermittent line can be run faster and that the buckets fill better; but, as there are only half as many buckets for the same number of links, the dredging capacity is less. An intermittent bucket-line will handle larger boulders than a close-connected one, and it is to be preferred in some cases for this reason.

To hold the boat against the bank and move ahead, either spuds or a head-line are used. Each method has advantages and advocates. A little time is lost in walking ahead with spuds, but the labor of burying "dead men" for the head-line and moving the latter by hand along a high bank is obviated; wider cuts can be dug, but they are ordinarily of no particular advantage. Spuds hold the dredge steadily against the bank and obviate the rolling and pitching, which are a disadvantage when the head-line is used. It costs more to equip a dredge with spuds, but they are generally preferred in Oroville when dredging in ponds. When working in swiftly running water, a dredge equipped with both head-line and spuds would be desirable.

Of mining costs in general, and of dredging costs in particular, it may be said that bare figures, without details of the items considered and of the local conditions, convey no definite information and are practically valueless. By a little bookkeeping dredging costs may be made as desired. If the figures included all expenses

incurred during the year, and an amount for the depreciation of the dredge, a much more satisfactory basis for comparison would be available. Amortization of the price of the ground manifestly varies with each case considered, and comparisons are useless. Owing to the slack methods of measurement frequently employed, the yardage quoted may easily vary 20 per cent.

The following table of costs applies to a 3 5-ft close-connected, bucket-line dredge working in the high-water channel of the Feather river, or adjacent thereto:

1903	Bank measurement, cu yd dug	Percentage of time in operation	Cost per Cubic Yard				
			Labor	Power	Repair and Supplies	General Expense	Total Expense
Dec	35,000	68 78	$.0382	$ 0221	$ 0130	$ 0398	$ 1131
Jan	37,000	67 61	0306	0173	0276	0023	0778
Feb	37,800	86 16	0276	.0199	0114	0062	0651
Mar	40,500	65 88	0250	0181	0038	0028	0497
Apr [1]	24,680	42 68	.0392	0170	0414	0035	1001
May	33,572	74 33	0322	0238	0370	0016	0946
June	44,878	87 76	0234	0173	0239	0022	0668
July	35,520	72 44	0315	0196	.0280	0018	.0809
Aug	49,340	84 80	0235	0131	0335	0010	0711
Sept	34,226	88 79	.0305	0190	0285	0032	0812
Oct [2] .	36,000	88 68	.0297	0229	0207	0319	1052
Nov	38,000	88 43	.0270	0199	.0433	0026	.0928
Dec	38,500	86 73	.0285	.0175	0087	0017	0564
Aver	37,309	77 11	0291	.0189	.0241	0075	0796

Gravel 30 to 45 ft. deep is considered easy digging by Oroville operators. Under the head of "labor" are included the superintendent's salary and such work on repairs as could be made without the aid of the local custom machine-shop. For December, the first month of operation, the costs are increased under the head of "labor," by superintendent's salary prior to start of actual digging; and under head of "general expense," by all the organization expenses of the company, the taxes on land and the insurance for one year. In April high water forced an entire shut-down, thus accounting for the small yardage. "Power" is increased by reason of the pumping of water from the river to the dredge-pond; it has since been found advisable to obtain water from a ditch at about $75 per month One new stacker-belt was bought during the year

[1] Flood. [2] Taxes and insurance.

and a 40-h p motor for the pumps, to replace one of 30 h. p which proved inadequate. While the bucket-line kept in good condition, there was no general replacement of parts, the bucket-backs being still in use in October, 1904. Stacker-belt No 3 was purchased in January, 1904, and is now about worn out with 8 months' use, although guaranteed for one year. This, with the expense of an entire new bucket-line stacker-belt recently purchased, and other parts, has kept the costs for 1904 somewhat above figures for 1903, although an increased yardage averaging over 40,000 cu. yd. per month has been dug. The table includes all expense incurred for whatever reason, but does not include interest nor a sum for amortization of the capital invested in land and dredge.

Above is a summary of the operating expense of a 5-ft intermittent bucket-dredge for the calendar year 1903. This dredge cost $45,000, which is much lower than that of the better class of dredges now being installed Most of the ground was fairly easy digging, but little tight gravel being encountered. Proportion of time in operation, 69 4; bank measurement, 474,610 cu yd. The average cost was as follows: Operative labor, 1.85c ; power, 1.15c.; repairs and supplies, 3 46c.; general expenses, 1.25c.; total, 7.71c. per cu. yd.

"Operative labor" includes superintendent's salary per cubic yard; "repairs and supplies" includes the labor of repairs, as well as the materials; "general expense" covers general expense at Oroville and at San Francisco, taxes, insurance, and bullion charges, beside the expenses of prospecting To the above should be added interest on the money invested, including the dredging plant and land, which may be assumed as approximately 0.75c. per yd., and about $4,500 for yearly depreciation of the dredge, say 1c. per yd. This brings the total expense close to 9.5c. per yd. Out of the profits there still has to be written off another amount to cover loss in the value of the land dredged.

The following figures for the month of September, 1904, were made by a new 5-ft., close-connected, bucket-line dredge, digging on a spud in soft ground 40 ft. deep, under very favorable Oroville conditions. Total excavation, 96,112 cu. yd. The cost of labor was 0.957c ; power, 0.999c.; supplies, 0.935c.; sundry, 0.4300c.; taxes and insurance proportion for the month, 0.1075c.; total, 3 4285c. per cu. yd. There was no charge for maintenance and repairs during the month.

All repairing necessary was done by the regular crew, no shut-down for that purpose of any moment taking place, thus accounting for the large yardage and the insignificant expense for repairs. On the other hand, costs for one company have run for several months together over 20c. per cu. yd., which shows the amount of variation encountered, and the erroneous impression given by costs which cover but a short period of time.

Figures recently quoted,[1] with no details as to items included, give yearly averages of from 4 92 to 7.47c. per cu. yd., the general average for a number of years being 6c. These figures may contain all legitimate charges against operating costs, notwithstanding the fact that the intermittent bucket-line type of dredge is used, as this particular company works under very favorable conditions, namely, dredging almost exclusively in the present river channel, thereby saving the cost of water and encountering only loose and easily dug gravel, and having a well-equipped machine-shop devoted to dredge-repairs and operating five dredges in the same vicinity.

The manager of this company, in common with others equally well informed, holds that the average of operating costs for the Oroville district is certainly not less than 7c. per cu. yd. at this time.

It is evident that with more than one dredge, items such as superintendence, repairs, office expense, etc., may be materially reduced. What the future may hold forth to operators of large and improved dredges is hazardous to say, but predictions are freely made of a cost of from 4 to 5c. per yd. under favorable circumstances.

Conditions favorable to dredging at a low cost must approximate those found commonly at Oroville, namely, a soft and not uneven bedrock, few boulders over 500 lb. in weight, gravel banks from 20 to 60 ft. deep and not sufficiently indurated to require blasting, a plentiful supply of water, cheap power, machine-shop facilities, nearness to supplies and means of transportation, mild winters and intelligent labor at reasonable wages.

Gold concentrated on a hard, rough bedrock cannot be dredged. Very large boulders have to be left with considerable gravel surrounding them, and, if many are encountered, dredging becomes impossible. In departing from the favorable conditions stated

[1] This JOURNAL, October 6, 1904, p 541.

above, the expense and difficulty of operation increases, necessitating a higher grade of ground for profit.

The conditions bearing on the cost of operation are such that each tract of ground becomes a problem in itself, and any attempt to use the costs obtained under one set of conditions, to predict those which would hold under others, without a thorough knowledge of the various elements which enter the problem, will lead to large discrepancies between the results predicted and those actually obtained, with a possible consequent failure of the enterprise. Much remains to be learned about gold dredging; but, in the future, as well as in the past, progress will no doubt result from the helpful professional spirit prevalent in the Oroville district. Good dredging conditions are not generally found with gravel deposits; but no form of mining gives more certain results, provided the average content of the deposit and the operating facilities have been found favorable by competent investigators, and a suitable dredge be installed.

THE BASIS OF VALUE

(Editorial, December 15, 1904)

THE recent break in the share quotations of the Amalgamated Copper Company and the Greene Consolidated Copper Company doubtless illustrates several of the vagaries of human nature and some of the eccentricities of speculation; but unlike as these two undertakings undoubtedly are in many respects, they bear one resemblance in the lack of proper information given to shareholders. It is manifest that when either the financial conditions or the metal markets affect adversely the quoted value of mining shares, those will suffer most which are rendered vulnerable by absence of reliable information. The daily press may very properly sneer at Mr. T. W Lawson and attempt to deny him his hard-bought notoriety by referring to him as "a Boston operator"; but the fact is that neither he nor any other adventurer could depress a security such as Amalgamated if it published proper reports and balance sheets. As it is, the helpless speculator knows nothing of the assets or of the intrinsic value of the property represented by his share certificates; it may be a South Sea bubble of iridescent air, and he might as well throw his money on the roulette table. We venture to say, however, that if a proper accounting of the business were given, accompanied by reports on the physical condition of the mines by the technical chiefs, such men as Mr. Benjamin B. Thayer or Mr Charles W. Goodale, the value of Amalgamated shares would rest on a solid basis of fact Similarly, in regard to Greene Consolidated, splendid mine as it is, nothing definite or satisfactory is given in the reports issued to shareholders Vague and flamboyant statements are issued by the president and a handsome production is undoubtedly being made, but none of the usual and proper estimates of ore-reserves are given to the shareholders—and without these, the rate of dividend, cost of copper, and so forth, are illusive. Here again, we venture to say that if such members of the management as Mr. Arthur S. Dwight or

Mr. W. B. Devereux were to make a report on the ore-reserves and future prospects, there would be given a stability to the investment in this copper mine such as it can never possess under existing circumstances. Whether people buy as gamblers or as investors, sooner or later they must face the facts, and the fundamental fact in a mining enterprise is the known quantity of ore in the mine.

EQUIPMENT AND ORE-RESERVES

(December 15, 1904)

The Editor

SIR—I have been greatly interested in following the discussion on "Ore-Reserves," together with your impartial treatment of the subject. It is an excellent illustration of the timely fruitfulness of developing a subject in this way. Indeed, I know of no greater service that the leading mining journal of the world can perform than to thresh out such puzzling questions by public discussion. Here is something practical. The faulting of the strata of the stock market may confuse many a wise and honest director or superintendent, who wishes to follow the pay-streak of honesty, and the vein of business.

Firstly, I would cordially agree with you in the wisdom of dealing frankly with the public. If ore-reserves are to be hoarded, let the knowledge of the fact of reserves be as open as is the existence of the mine itself. Indeed, there is no more signal mark of ethical progress, in civilization at large, and in the control of business in particular, than the growing demand by the people for a free, open statement of the respective facts. The people may not always get this, but they have learned to ask for it; and in this I presume that *vox populi* is *vox Dei*.

But secondly, assuming, to be specific, that the contrasted views of Mr. Hoover and Mr. Curle represent the opposite opinions of the speculator and of the investor respectively, is it fair to formulate the questions at issue from the standpoint of either, or, for that matter, from a standpoint intermediate between both? That is, may there not be other and more powerful considerations of business, to the demands of which the private interests of both investor and speculator must conform? It may be true, for the present—as the speculator is furnishing most of the money necessary to develop mines—that his interests must be consulted; this may be a present business necessity But is it possible to educate the speculator to the more rational views of the investor? And

is it possible, in turn, to quicken the investor with the speculator's practical keenness for results? And to do both so that business practice may attain that method of mine management which is best for all concerned in the long run?

Then, thirdly, what will best serve the real purpose of capital invested? If the application of actuary mathematics to such problems were highly developed, it would be necessary only to refer to a manual of dividend accumulation, amortization of investment, sinking fund reduction, etc., to know at once what are the financial forces that are competing for control as this complex of interests seeks its natural equilibrium.

Now a mine, even a large one, with large, well-defined veins carrying a generous supply of ore, even this is not like a farm which may go on indefinitely producing from the same ground year after year. An exhausted mine is simply an empty, worthless hole in the ground; and this may be the destiny of all mines. This view would seem to argue distinctly for the speculator. The mine is bound to be exhausted sooner or later; working it is like the threshing of this year's wheat crop; let it be done and done as quickly as possible, so as to release the capital for employment in other fields. The illustration is good; but it is not an argument. It is at best only an analogy which can be applied to *certain mines*, namely, those which can be quickly exhausted As for the other class of mines, those like the Treadwell, the Homestake, or better still, some imaginary reef or mountain—as the gold in the ocean, for instance—which might be practically inexhaustible, in such cases would not the policy of counting on long supplies for the long investor be the better?

This, then, is the suggestion that I would make, and I wish you would so discuss it. Is not the interest of the transient speculator, represented by Mr. Hoover, justified by the conditions of some mines? And, on the other hand, is not the interest of the long investor, represented by Mr. Curle, equally well justified by the conditions of other mines? Do not both views represent some truth—but only as applied to special cases? Will it not be well to continue the discussion till we may see clearly brought out the particular kind of mine to which applies, respectively, the interest of the investor and of the speculator?

C. S. PALMER

New York, December 5, 1904.

LEASING AT CRIPPLE CREEK

(December 15, 1904)

The Editor

SIR—There has been a considerable improvement lately in the output of the Cripple Creek district, both in quantity and quality of ore. Simultaneously there has been a decided extension of the leasing system both in practice and in popular favor. Undoubtedly a portion of the improved results are due to the success of many leases—especially on Stratton's Independence. It occurs to me that a discussion of the merits and province of the lessee as compared with those of the company's miner and mining engineer may interest a portion of the mining public.

Many suppose that the reason why lessees often do markedly better than companies is that they get more work out of their men and do a good deal of the work themselves. Undoubtedly in general this is true, but the importance of this point is much less than many imagine, and there is no reason why a mine superintendent cannot make his men work just as hard as a lease superintendent can. In fact, it is possible for a mine superintendent to accomplish just as good results for his company as a lessee can for himself. Many leases of importance in the Cripple Creek district are managed by hired superintendents, just as mining companies are. In my opinion the superiority of the lessee comes from the fact that his training qualifies him to find ore and mine it to the best advantage. He is often aided by the fact that he has no professional record to make. He is not worried about costs per ton. His sole object is to make money, and he makes it by shipping clean ore.

Nobody hears of leases in any mines except those where (1) the ore is a concentrating one, or (2) the finding of the ore is the principal part of the work. It is curious to note how little there is in mining literature on the subject of mining concentrating ores. By concentrating ore I mean an ore in which the metal sought is not uniformly distributed through the mass; in other words, an

ore consisting in large part of worthless rock which must in some way be separated from the valuable mineral. Most of the mines in the Rocky Mountain region are of this character The handling of such orebodies affords a much greater scope for intelligence and business judgment than does the extraction of a body of uniform ore. In the latter case, one's efficiency can be measured in cost per ton of ore mined. In the former, one's efficiency must be measured by the cost of metals produced. It is not fair even to make a comparison of the cost of concentrates; in the case of lead ores, for example, one man may take a 50 per cent concentrate and another a 70 per cent. Obviously in a concentrating proposition the main effort is to get rid of the worthless gangue and save the valuable metal. Whether this gangue can best be removed in the process of mining, or in a concentrating mill, or partly in both, is often a question upon the solution of which depends the success of a mining venture.

In Cripple Creek the ores are almost universally of the mixed type. They will not yield to ordinary methods of water concentration. After the ore is broken it can only be separated crudely by means of screening, supplemented by hand-picking; but the concentrating can be begun at the moment the drilling begins underground by taking care to break nothing except what will pay. There is plenty of room for skill and experience in determining such questions as the following: (1) what ground to break and what to leave; (2) where to put the holes and how much powder to use in breaking in order to leave the rock in the best condition for effective sorting; (3) whether it is best to sort underground, or on the surface, or both; (4) whether to use hand-drills or machines; (5) what appliances to use in the shape of washers, sorting-tables, picking belts, etc., etc.

Each of these questions of handling the ore may, and does, vitally affect the lessee's pocketbook. He must do his mining solely with a view to making profits, for profits he must have or quit. A mine manager may go through the motions of mining in apparently good style. He may have nice machinery, good pumps, elaborate reports, accurate cost-sheets—and no profits. He may mine large orebodies at small cost. He may point with pride to the very things that ought to condemn him as hopelessly incompetent. He may be mining too much and mining too cheap. In saving at the spigot he may be losing at the bung.

The lessee rarely commits such blunders. He thinks solely of dollars and cents. He makes no reports and seldom bothers about indicator cards, but he watches his ore like a hawk and mines it right. He ignores the frills and attacks the substance of his business.

So far so good But the lessee's limitations are also conspicuous. Ordinarily his interest in the property does not extend beyond the hope of making some money out of a limited block of ground. His development work is apt to be done grudgingly and with little attention to its subsequent utility. In mines that have been partially developed by the leasing system it often happens that the entire mine must be re-opened on more comprehensive lines before it can be worked out. It usually happens also that the owners fall back at last upon the services of hired managers who, while having some qualifications that the lessees lack, are deficient in the very important practical virtues that the lessees possess.

It seems to me that the lessee fills a peculiar province in the mining business that is essentially his own—that of furnishing the hard common sense and practical enterprise necessary to exploit doubtful and poorly managed mines. He has to take chances, and in taking them he is rewarded by a certain percentage of successes. He takes chances that a thoroughly competent mining engineer might not be willing to advise.

There is much that the average lessee knows which should be essential to the success of every mining operator, but which is strangely neglected by many There are some mine managers who appear to forget that their business is *mining*, and who neglect the problem of handling the ore to spend their time on refinements which may be of importance, but which ought to be left to others. I believe it to be rare that any amount of technical knowledge is of sufficient value to cover up a deficiency in the knowledge of plain, straight mining. When the lessee demonstrates by his success that such deficiency has existed elsewhere, he is doing the business and the profession a great, but perhaps unconscious, service.

J. R. Finlay.

Colorado Springs, November 14, 1904.

SECRECY IN MINING

(Editorial, December 29, 1904)

The West Australian Commission, empowered to hold an inquiry into the fiasco arising from the manipulation of shares in the Boulder Deep Levels at Kalgoorlie, has presented its report to the State government. It is recommended:

"(1) That all mines shall be open to inspection by shareholders at convenient hours. (2) That the Minister of Mines shall be empowered to authorize an official to take samples from any property, inspect the working, and (3) compel the companies to keep assay plans, also plans of the underground workings where they will be available for inspection by shareholders. (4) It is further recommended that misrepresentation or concealment of facts shall be punishable by fine or imprisonment, and (5) that managers' reports shall be published locally coincidently with their reaching the head office. The Commission says that the enforcement of these recommendations will put an end to secrecy adopted by some mines."

The intention of these recommendations, in so far as they signify the lifting of secrecy from the operations of mining companies, is well enough. Wrong-doing grows in the dark; the opening of doors and the admission of light will do much to check the rascality from which mining investments suffer. Admission to mines should be regulated so as not to impede operations, and it should include the experts engaged by shareholders, as well as the shareholders themselves. A limit as to the number of inspections permitted during a given period would be a reasonable check upon a practice which might degenerate into a nuisance. If the Minister for Mines is to be empowered to send an official to inspect, then the Minister himself, no less than his deputy, must on no account be the possessor, buyer, or seller of the shares of any mine in the region over which he holds this authority. Assay plans and maps are necessary to all mines, whether large or small; and this recom-

mendation should meet with unqualified approval. We presume that, in order to punish misrepresentation and concealment of facts, the intention to defraud would have to be proved; this is a legal matter, the settlement of which is unimportant, for if secrecy is eliminated, misrepresentation will be unsuccessful. The publication of reports locally, as well as in London, is reasonable; it will work no hardship on the shareholders in Europe or elsewhere, and it will be a proper concession to Australian shareholders. If the Western Australian government imposes such a condition, we do not see why the Englishman should object. This also will serve as an obstacle to the manipulation of the local stock market, by encouraging the diffusion of official information simultaneously at both ends, the head office in London and the place where the mine is situated. Everything that tends to give shareholders full information, works for the investment aspect of mining; changes in the physical condition of a mine are frequent, but these account for only one-quarter of the fluctuations in shares A straightforward policy gives security, and without that a mine becomes merely the sport of gamblers.

MINE VALUATION

(Editorial, January 19, 1905)

ON another page we reply to a correspondent in Mexico, who asks for an explanation of the use of annuity tables in the appraisal of mine shares, and we have taken the opportunity to publish Inwood's tables, which are used by investors in South African mines. To some of our readers, it will seem absurd to apply such methods to the cheerful gamble of a mining venture; and to these same readers, the vagaries of gentlemen from Arizona and prophets from Boston are fit and proper adjuncts to an industry the importance of which to us, on the other hand, can be gauged not only in terms of money, but also by the education and character of the profession which tries to serve it faithfully, despite the careless disregard of an ignorant public. To many speculators, the talk of amortization of capital, return of investment, life of mine, and other financial terms indicative of serious business, is only an irritation; and, when you speak to them of the necessity of a mine paying back the market valuation, plus interest on the investment, they grow weary. But it does not need a long lifetime to appreciate the fact that mining is slowly emerging from the muddy shallows of spurious finance to a dignified business; and, if our insistence on certain fundamental principles can contribute to that end, one of the purposes of this JOURNAL will be fulfilled. It is pitiful to notice how the daily press, in its comment on the Montreal & Boston imposture, appears to accept a low standard of morality as inherent in mining affairs, without so much as a side glance at disgraceful messes such as that of the Shipbuilding Company, and other industrial undertakings whose sponsors sit in high places.

Those who buy shares to sell them at a higher price usually have little regard for niceties of valuation, and consider, properly enough, that market conditions are a more important factor than any academic ratiocinations; but, even for those gentlemen who dabble on the dangerous margin of the financial rapids, it will be

found well to have an idea of that which is the fundamental basis of their speculations. Sooner or later, they must face the facts; every speculator eventually fails to find one more reckless than himself Ore-reserves, and profits derived from them, are the essence of successful mining enterprise; without them, the mine is only a hole in the ground. Dividends indicate the surplus of a moment; they are no criterion of future returns, unless these are insured by accurately measured reserves of ore. Low costs are a symptom of healthy economy, but they do not guarantee profits, they simply prove that the minus quantity to be deducted from the value of the production is relatively small. Good management does not make a mine; it is only an aid. We sympathize with the unfortunate Britisher who, after several experiences with poor mines and good managers, is said to have exclaimed that in future he would invest in mines that could stand bad management. Properly ascertained resources in the form of orebodies, thoroughly sampled and measured, are the only assurance of the long life of a mining enterprise; and, without such assurance, it is not an investment. But this does not belittle the worthiness of sensible speculation, which has been, and ever will be, the quickest way to make money. We simply desire to emphasize the essentials of an "investment," which is the attractive term too generally applied to schemes of an essentially speculative character. Pay your money and take your choice; but, for the sake of sound mining, let us make distinctions which are essential.

MINE VALUATION

(January 19, 1905)

The Editor:

SIR—I quote from the editorial in your issue of December 8, 1904, entitled "The Logic of Valuation": "In the first place, an investment in a well-developed copper mine should yield 10 per cent; secondly, 5 per cent should be set aside for a sinking fund to redeem the principal. By the annuity tables, it is found that, assuming 10 years' life for the mine, the number of years' purchase of dividend to yield 10 per cent income and redemption of principal at 5 per cent compound interest is 6.14 years. This 6.14, multiplied by the annual dividend — \$4.80 — makes \$29.47, say, \$30, which is the amount that should be paid per share to give the purchaser 10 per cent income, and return to him, at the end of 10 years, the price which he paid for the share."

I encounter this question of "so many years' purchase, at so much income, and redemption of principal at a certain interest," very frequently; and I am free to say that it is obscure to me, though I have no doubt it works out in a very simple form. As a matter of fact, this whole matter of capitalization of a debt, annuity, etc., amortization, number of years' purchase of dividend, sinking fund, and annuities is only vaguely understood by me, and I should like to obtain some convenient manual whereby I can post myself thoroughly. Can you recommend anything on the list of works handled by your JOURNAL that will fill the bill?

There may be others among your subscribers whose experience with financial questions of this particular nature is as limited as mine; and if you would elucidate the point mentioned in your editorial, you would confer a favor on us all.

E. H. W.

Parral, Mexico, December 19, 1904.

[The amortization of capital invested in equipment as related to the decreased cost attained by such additional machinery has

been discussed in this JOURNAL by several writers, notably Mr H. C Hoover, in our issue of March 24, 1904. A discussion ensued, and to this our correspondent is referred Amortization is the recovery of capital invested, at the end of a certain term. Number of years' purchase means the number of annual profits which together represent a return of the capital; a mine sold for $100,000 is bought at five years' purchase if it yields $20,000 profit per annum. The question of life and return of capital on the basis of an annuity is a more complicated question. In 1811 Inwood's tables were first published; they give the present value of an annuity at different rates per cent for any number of years and replacement of principal on termination of the annuity. What immediate lump sum must one pay to receive $25 annuity and have the money paid for the annuity replaced at the end of 25 years? The tables in question give the answer in the form of the number of years' purchase of the annuity. At 5 per cent, the present price to be paid for a 25 years' annuity is 14 years' purchase of annuity. These annuity tables can be applied to the valuation of mine shares, and they have been so applied by the investors in South African mines. We applied the method recently, as quoted above by our correspondent. Of course, as a rule, mining enterprises do not lend themselves to such logical treatment, as investors rarely lock up their scrip for five or ten years, either actually in a safe or mentally, by their way of regarding their commitments. But the mine which has ceased to be a prospect—essentially a gamble—and has developed even beyond the early stages, when it is a highly speculative risk, to that stage of assured productiveness which warrants the application of the term "investment"—such a mine can be valued in a logical manner or else it should be let alone. For the convenience of our readers we add the annuity tables referred to, as they appear in "The Mines of the Transvaal," published by *The Statist*, a London financial journal which has done good work in this department of mining business.—EDITOR.]

NUMBER OF YEARS' PURCHASE OF DIVIDEND TO YIELD 6 TO 10 PER CENT INCOME AND REDEMPTION OF PRINCIPAL (5 PER CENT COMPOUND INTEREST)

"Life"	At 5 Per Cent	At 6 Per Cent	At 7 Per Cent	At 8 Per Cent	At 9 Per Cent	At 10 Per Cent
1	.95	.94	93	93	92	91
2	1 86	1 83	1 81	1 78	1 76	1 74
3	2 72	2 67	2 62	2 58	2 53	2 49
4	3 54	3.46	3 39	3 31	3 24	3 17
5	4 33	4 21	4 10	3 99	3 89	3 79
6	5 01	4.92	4 76	4 62	4 49	4.36
7	5.78	5 82	5 40	5 21	5 03	4 87
8	6 46	6 21	5 97	5 75	5 53	5 34
9	7 11	6 80	6 51	6 25	6 00	5.76
10	7 72	7 36	7 02	6 71	6 42	6.14
11	8 30	7 89	7 50	7 14	6 81	6.50
12	8 86	8 38	7 94	7 54	7 16	6.81
13	9 39	8 85	8 36	7 90	7 49	7.10
14	9 90	9 30	8 74	8 24	7.79	7 39
15	10 38	9 71	9 11	8.56	8 06	7 61
16	10 84	10 10	9 45	8 85	8 31	7.82
17	11 27	10 48	9 76	9.12	8 54	8 02
18	11 69	10 83	10 06	9 37	8 76	8 20
19	12 08	11.16	10 33	9.60	8 95	8 37
20	12 46	11 47	10.59	9 82	9 13	8 51
21	12 82	11 76	10 83	10 02	9 29	8 65
22	13 16	12 04	11 06	10 20	9 44	8 77
23	13 49	12 30	11 27	10 37	9.58	8.88
24	13 80	12 55	11 47	10 53	9 71	8 99
25	14 09	12.78	11 65	10.67	9 82	9.08
26	14.37	13 00	11 82	10 81	9 93	9.16
27	14.64	13 21	11 98	10 94	10.03	9 24
28	14 90	13 41	12 14	11 05	10 12	9 31
29	15 14	13 59	12 28	11 16	10 20	9 37
30	15.37	13.76	12.41	11.26	10.27	9.43
31	15 59	13.93	12 53	11 35	10 34	9 48
32	15 80	14 08	12 65	11 43	10 41	9 53
33	16 00	14 23	12.75	11 51	10 46	9 57
34	16 19	14 37	12 85	11 59	10 52	9 61
35	16.37	14.50	12 95	11.65	10 57	9.64
36	16 54	14 62	13 03	11 72	10 61	9 68
37	16.71	14 74	13 12	11.78	10 65	9 71
38	16 87	14.85	13.19	11.83	10.69	9 73
39	17.02	14.95	13.26	11 88	10.73	9 76
40	17.16	15.04	13.33	11.93	10.76	9.78
45	17 77	15.46	13 60	12 11	10 88	9.86
50	18.25	15 76	13.80	12 23	10.96	9 92

GRAVEL-MINING COSTS IN ALASKA AND NORTH-WEST CANADA *

By Chester W. Purington

(February 9, 1905)

The data in the table on page 277 have been compiled from statistics collected during a recent inspection of the placer fields in Alaska, Yukon Territory and northern British Columbia. Of the statements furnished by operators, only those which are considered reliable have been used. The work attempted had no relation to the sampling or valuing of mining properties, and time did not permit, usually, of the measuring of the ground.

Owing to the varying conditions governing the cost of mining in the North, the territory has been divided into three provinces. The South Coast province includes the Juneau, Porcupine and Sunrise districts of Alaska. The Interior province includes the Atlin district of British Columbia, the Klondike district of Yukon Territory, and the Fortymile, Eagle, Birch Creek, Fairbanks and Rampart districts of Alaska. The Seward Peninsula province includes the Nome, Council and Solomon districts of Alaska. The Nizina district of the South Coast province, and the Port Clarence, Fairhaven, and Kugrok districts of the Seward Peninsula are separately considered.

In preparing the sheet, the working costs of 118 different operations were first tabulated with reference to the method employed and to situation. A second table was then prepared, in which the

* The figures that are given here are extracted from a report on the "Costs and Methods of Gravel and Placer Mining in Alaska," and here published by permission of the Director of the United States Geological Survey. The data furnish as near approximations as the nature of the work permits The cost of all supplies, rates of transportation, cost of labor, and description of water, timber and fuel resources in all important parts of the territory, as well as full descriptions of all the methods of mining employed, will be given in the final report.

working cost was augmented by an amount per cubic yard based on allowance for depreciation of plant. A general figure of six years was taken as the average life of an individual property, and, except in the case of winter drifting operations, 120 days as the

Capacity in Cubic Yards per 24 Hours Cost in Dollars and Cents per Cubic Yard ***

	1 Hydraulicking, no pumping of water.	Cost	2 Hydraulicking with use of hydraulic lift	Cost	3 Open cut shoveling into sluice- [illegible]	Cost	4 Open cut horse scraping	Cost	5 [illegible]	Cost	6 Open cut; shoveling into cars; track and incline to sluice	Cost
South Coast Province:		$		$		$		$		$		$
Number of operations considered	6		6		6				.		.	
Capacity cubic yards in 24 hrs	833		300		54				.			
Thickness of deposit in feet	30 3		25		5 6							
Thickness gravel worked in feet	30 3	.20	25		3 7	2 01						
Interior Province												
Number of operations considered	13		.		20				8			
Capacity cubic yards in 24 hrs	1040		.		63		105		162		450	
Thickness of deposit in feet	37 4		.		8 6		20		17 5	.	14	
Thickness gravel worked in feet	37 4	238 24	.		3 5	2 39	10*	60	4 5	2 14	5	2 43
Seward Peninsula Province:												
Number of operations considered			4		10		5					
Capacity cubic yards in 24 hrs			608		145		200	.				
Thickness of deposit in feet	..		12	.	6 6		5					
Thickness gravel worked in feet		.. .	12	.89	3.3	1 87	5	.46				

	7 Open cut; shoveling into buckets or skips skidding or tramming and derricking to sluice	Cost	8 Open cut shoveling into sluice tailings by hydraulic lift	Cost	9 Open cut steam shovel excavating; track and incline to sluice	Cost	10 Open cut steam scraping generally on stripping work or tailings	Cost	11 Dredging	Cost	12 Drifting partly frozen or thawed ground requiring timbering	Cost
South Coast Province:		$		$		$		$		$		$
Number of operations considered			.									
Capacity cubic yards in 24 hrs												
Thickness of deposit in feet												
Thickness gravel worked in feet												
Interior Province												
Number of operations considered					.		6					
Capacity cubic yards in 24 hrs	235		184		800		92		1062		50	
Thickness of deposit in feet	15		8		22		15		35		60	
Thickness gravel worked in feet	9	1 75	6	1 25	22	1 46	8 7	.49	35	.49	4	4 25
Seward Peninsula Province:												
Number of operations considered												
Capacity cubic yards in 24 hrs	550				1000				700		80	
Thickness of deposit in feet	15				30				8		20	
Thickness gravel worked in feet	11	.91		.	27	.52			8	.43	7	4 49

	13 Drifting and thawing solidly frozen ground little or no timbering	Cost	14 Winter drifting and sluicing of dumps	Cost	15 Mining or stripping overburden by ground sluicing	Cost	16 Hydraulicking by means of pumped water	Cost	17 Booming with self dumping water gate	Cost
South Coast Province:		$		$		$		$		$
Number of operations considered										
Capacity cubic yards in 24 hrs										
Thickness of deposit in feet										
Thickness gravel worked in feet										
Interior Province										
Number of operations considered	7						4			
Capacity cubic yards in 24 hrs	75		90		150		830		250	
Thickness of deposit in feet	26 4		26 4		9		33		7 5	
Thickness gravel worked in feet	4 36	3 38	4 30	5 14	9**	.17	33	.65	6*	.07
Seward Peninsula Province:										
Number of operations considered							3			
Capacity cubic yards in 24 hrs	20		83		173		250			
Thickness of deposit in feet	35		85		4		23			
Thickness gravel worked in feet	4	3.66	4 3	4 61	4**	.10	23	.93		

* "Muck" and top gravel ** "Muck" or fine silt and ice, from 50% to 75% ice *** Lost time, prices paid for mining property, and cost of equipment other than mining (railways, wagon-roads, etc.), are not included Any estimates based on the figures here given should take into account these expenditures, otherwise the costs will be too low

working season. It was then assumed that five annual payments are made to a depreciation fund. The fund is equivalent to the cost of plant and maintenance of same during the life of the property, plus six years' simple interest on the investment at 5 per cent. Each annual payment was divided by the season's output in cubic yards, and the amount thus obtained added to the daily working expenses, to get the total output cost per yard, as far as possible. Prices paid for mining property are taken no account of, as they

represent an unknown factor. In cases where expensive plants have been installed the amortization was separately figured for each case. In cases of shoveling-in and small mechanical plants, the installation and maintenance cost was taken at an average amount for a group of operations in each district. Where the operation implies an additional stripping of overburden, which is always separately charged, the cost was distributed and added to the gravel extraction cost.

From the second table, where the costs were reduced to one figure for each district, a third table (as given) was prepared, giving as nearly as possible the average cost for each of the 17 separate methods considered in one or more of the three provinces. Where the operations from which the averages are derived exceed two in number, the fact is so indicated in the table

The attempt has been made to reject figures which were evidently not representative. The final figure arrived at is not, however, always satisfactory. For example, under No. 5 (the method of working open-cut by shoveling into wheelbarrows, wheeling to bucket, hoisting and conveying to sluice by self-dumping carrier or cable), $2.14 is representative for the Klondike, where seepage water is generally pumped from the pit, and many operators pump the water for sluicing. On the other hand, a plant in the Birch Creek district of Alaska, mining only 22 cu. yd per day, and handling the water by a drain, operated at a cost of $1.50 per cubic yard. In No 13 (drifting solidly frozen ground, steam or hot-water thawing, hoisting and conveying with the use of the self-pumping bucket), the cost in the Klondike is $1.95; while the higher figure given is arrived at by combining the expensive American camps of Fortymile and Fairbanks, where the cost is $4.63 and $3.56 respectively

The high cost of hydraulicking with use of hydraulic lift, in the Seward Peninsula, is caused by the difficulty of moving the gravel to the bedrock sluice,[1] and the expense of the ditches and installations. Hydraulicking by means of water under natural head without the use of the hydraulic lift, or some other means of elevating the material, was not seen in the Seward Peninsula. It is known that a hydraulic plant is in successful operation at Bluff, 50 miles to the east of Nome, but no data are available. In the

[1] This difficulty is due, not only to the exceedingly gentle grades of the streams, but also to the shingly character of the material handled.

interior, only bench gravels are hydraulicked. Steeper grades for sluices can be obtained, and the gravel is more easily moved. The high duty of the miners' inch in the Klondike is a large factor in bringing down the cost of No 1 and No. 16. It should be distinctly understood, if hydraulicking costs in the interior appear attractively low, that the water supply is exceedingly variable, and that no reliable estimate can be made beforehand of the output of a given season's operations Furthermore, while much of the bench gravel was originally rich, the pay-streaks have been largely drifted out, and the gold is not disseminated through the upper portion of the gravel to the extent that it is in California. With regard to the pumping of water for hydraulicking, the practice cannot be too strongly condemned. He is a bold man who attempts it, and a singularly fortunate one who makes a financial success of it

Mr. Stephen Birch, operating in the Nizina district of Alaska, has courteously furnished, for this report, a summary of the costs of working placer ground on Dan creek. These figures are given herewith, as they imply a total charge of invested capital, in addition to working costs against one season's operations.

By ground sluicing through 20-in. flume, 6,803 cu yd., $8,781.44, or $1 14 per cubic yard.

By use of 8-in. cotton-pressure hose and nozzle, through 20-in. flume, 1,600 cu. yd., $1,457 00, or $0.91 per cubic yard

Use of pick and shovel only, through 10-in. sluice-box, 2,320 cu. yd., $5,100, or $1.87 per cubic yard.

273-ft. tunnel, 6 by 6 ft, timbered, $1,017 00, or $3.72 per running foot. Or 407 cu. yd. of gravel removed, which cost $2.50 per cubic yard.

Mr. Birch adds: "While the cost may seem high, it is because of the fact that it includes the tools and material now on hand, which were necessary to remove this gravel. Now, if this work is continued for a number of years, the depreciation of the tools, etc., could be charged proportionately. These prices may not be a criterion for future operations in that country, but were our first cost of operation, and any strangers going into that section of country would be apt to run up their costs to these figures."

The cost of shoveling into sluice-boxes in the remote parts of the Seward Peninsula reaches to $5 per cu yd., and even higher. Some drifting operations have been carried on in the Kugrok and Fairhaven districts, figures on which are not at hand.

Dredging estimates furnished by reliable interior operators place the cost at 80c. per cu. yd., where gravel must be thawed by points ahead of the dredge. In the Seward Peninsula it is estimated that if the property is sufficiently large for a 10-year life to be allowed, a dredge can be operated at the cost of 30c. per yd The field for dredges in placer mining in Alaska is extremely limited. In the Seward Peninsula it is not impossible that some of the wide, shallow creek deposits will be worked successfully by means of the steam scraper The cost of an experimental operation on Ophir creek was said to be under 20c. per yd.

The costs of operating by two mechanical systems, in the Seward Peninsula (involving the labor of men in shoveling into cars and tramming, in the one case to the bottom of an incline, and in the other to a bedrock sluice leading to hydraulic elevator throat), are unfortunately not available for publication. The derricking system, No. 7, however, both in the interior and the Seward Peninsula, appears to be superior in point of cost to either of the above mentioned, for the working of the average Alaska open-cuts.

Frozen ground cannot be attacked with success by the steam-shovel. Even where it digs the gravel successfully, if men follow it clean to bedrock by hand, the cost of operating is sometimes doubled. The steam-shovel has, however, a field in northern placer mining.

Regarding mechanical operations in general, the important principle should be emphasized that the main expense is getting the material into the receptacle which conveys it to the sluice or washing plant. Tramming, even for a long distance and to a considerable elevation, adds a very small proportionate amount to the total cost of working. The establishment of a permanent washing plant, economically situated, as regards water supply and dump, should be considered by every Alaskan miner who proposes working the shallow creek deposits which characterize that country. The isolation of the washing operations, together with the adoption of the most economical system of tramming possible, will go far toward attaining the ends of adequate grade and room for tailing, which are the *sine qua non* accompaniments of successful gravel mining.

THE COST OF MINING

(Editorial, February 16, 1905)

On another page we publish a suggestive contribution by Mr W. R. Ingalls on the cost of mining, a subject of the utmost importance. Whether regarded in its broad economic aspect as implying the whole process of winning the metals, or in the narrower sense as covering only the actual breaking of ore, the question is one which must appeal to the readers of this Journal in a most practical way. Just as in ordinary life it is a proverb that money is easier to make than to keep, so in mining it is not too much to say that the finding of ore requires less skill than the beneficiation of it; at all events, the haphazard methods of the one must ever be in strong contrast to the logical ways of the other The subject presents many aspects, each of which invites discussion. There is the general question of the attainable minimum of expense as affecting the world's output of metals, and the relation of the growing rate of labor to the increasing application of machinery; there is the accountant's and director's view of the portion of cost properly chargeable to mining, with a glance back at the days when development was charged to capital account, and perishable machinery to assets. There is a general inquiry into the conditions which cause costs to vary within such wide limits in different mining regions, and the pertinent subject of the factors contributing to particularly creditable results at individual mines. Finally, there comes the broad problem of practice underground, where more money is lost or saved than is dreamt of in the philosophy of the average investor. These are but suggestions; our own views will find expression at a later date, when our friends will have given a good start to a discussion, the obvious usefulness of which should elicit a widespread expression of experience and opinion.

THE COST OF MINING

By W. R. Ingalls

(February 16, 1905)

There is perhaps no subject more difficult to generalize. The cost of mining varies according to conditions in a manner so obvious as to require no antithetical citations. There can be no question as to what constitutes the ultimate cost of mining, but opinions differ as to what enters into the cost during a limited or arbitrary period, such as the fiscal year; in other words, accounts are kept in various ways. Many other difficulties may be mentioned. Notwithstanding all these, it is worth while to attempt some generalizations, making due allowance for the variables, since it is only through such deductions that we obtain standards for comparison.

The determination of standards would be useful in at least three ways: (1) They would enable the mine superintendent to know if his work were being done as cheaply as it ought to be by comparison with the cost of similar work elsewhere; (2) they would stimulate efforts to reduce expenses, since a knowledge of the cost of each part of the work indicates the direction where economy can be effected, and (3) they would furnish the engineer who has to value mines, especially new mines, with improved means of estimating the probable cost of mining, and therefore the net value of the ore. The cost of keeping accounts, even in the fullest detail, is so slight that there is no good reason why they should not be kept in a thoroughly instructive manner. The value of any accounting is greatly diminished if it be not so systematized as to give all the information that may be commercially or technically required.

At the present time there is a great lack of recorded information such as will furnish the desired guidance to the engineer. It is a frequent practice to estimate that because a certain orebody is being mined in one place at a certain cost, a supposedly similar

orebody may be mined at another place at approximately the same cost. Such comparisons are useful as checks, but constitute an untrustworthy basis for estimates, unless the analogies are thoroughly demonstrated, since in the outcome it often happens that the actual cost of mining proves to be widely different from what was forecast, because of peculiarities in the particular orebody and its occurrence that had not been taken into account

I have recently had occasion to examine several reports on a large deposit of low-grade ore occurring in a locality where there was not much mining precedent. The grade of the ore was low, and the successful exploitation of it depended upon a large tonnage being handled at a close margin of profit. It was a case where the probable cost of mining should have been estimated with the utmost precision, and by the application of engineering principles it could have been done. The mine was examined by three well-known professional men, of whom two at least had wide experience in such work. The cost of mining was estimated by one of them by a rather far-fetched analogy; the other two simply expressed the opinion that it would probably be a certain amount per ton, no reasons being given, and no references to the conditions affecting the cost The estimates of mining and treating the ore were certainly at fault somewhere, since the mine proved unsuccessful.

If, in estimating the cost of mining, as in estimating the cost of smelting and other engineering processes, the estimate be divided into its elements—the probable cost of the various parts of the work that go to make up the total—peculiarities affecting the total cost are much more likely to receive critical attention than when a lump estimate is made without any analysis.

The presentation of a detailed estimate in a report on a mining proposition is a good deal more convincing, especially to consulting engineers, to whom the report may be submitted, than the statement of a single figure for the total, which furnishes no evidence as to its accuracy, and in many cases can be pronounced no more than "probable" or "improbable" or some other uncertain characterization. It may be suggested that (in view of the numerous reports that are circulated without any information as to the cost of mining, cost of plant, etc., which it is necessary to know about, leaving it to the investigator to determine those factors) we should be grateful for what little is sometimes offered, and so we are, but

it is not that class of mining report to which I am referring in this article.

In venturing the suggestion that it is possible to forecast the probable cost of mining in a more rational manner, I feel sure of my ground, through the knowledge that there are many engineers who are not content to express inferential opinions, but analyze the various conditions that affect the cost of stoping, tramming, hoisting, timbering, pumping, etc., and that there are such technical papers as that of Kinzie on the mining and milling methods at Douglas Island, and that of MacDonald on the method and cost of mine timbering at Rossland, and many others of the same class, which go thoroughly and lucidly into the engineering conditions. We need more papers of that character which will give information as to the unit costs under numerous and various conditions, and especially the unit requirements of labor, in hours of work, and material, in pounds, tons and other measures.

In making analyses of costs for purposes of comparison, it is essential that the basis for itemization shall be as nearly uniform as possible. Some recently published statements have permitted the following tabulation, which, though admittedly imperfect, will certainly prove suggestive:

Item	A[1]	B[2]	C[3]
1. Miners and helpers	$0.35	$0 435	$0 429
2 Trammers, shovelers, etc	0 41	0 365	0 790
3. Drill sharpening and repairs	0.15	0 120	0 261
4 Compressed air	.	0 120	0 083
5. Maintenance of cars	0 03	0 090	0 038
6. Explosives	0 13	0 145	0.092
7. Timber	0.28	0 110	0 205
8 Timbermen	0 23	0 190	0.067
9 Hoisting	0 23	0 190	
10. Pumping	.	0 035	
11. Supplies, n e.s[4]	0.04	0.040	0 105
12. Supervision[5]	0.23	0 225	?
Total	$2 07	$2.065	$2 070

[1] Cripple Creek, Col. (reported by J R Finlay)
[2] Centre Star Mine, Rossland, B C. (official report)
[3] Bunker Hill and Sullivan, Cœur d'Alene (official report)
[4] Including all supplies not elsewhere specified.
[5] Including bosses, assaying, surveying.

The above classification appears to me quite useful, although for thorough comparison we ought to know the rates of wages,

consumption of certain material (especially coal) and prices of the principal materials. Items 1, 3, 4 and 6 give substantially the cost of breaking down the ore; items 2 and 5 the cost of loading the ore and delivering to the shaft, item 9 the cost of hoisting and delivering at the surface; items 7 and 8 the cost of supporting the ground, and item 10 the cost of keeping the mine dry. Each of these steps in the work is likely to vary rather widely in different mines. The ups and downs may offset each other and make the totals about the same, as, for example, in the three cases given above, but they may not.

There are comparatively few mining companies which report their costs with the above detail. Numerous companies, however, report costs itemized as follows: 1, labor, 2, coal; 3, timber; 4, explosives; 5, other supplies; 6, supervision; 7, administration and general expense. Such a statement is useful, but it is more useful if the items are subdivided according to the various branches of the work

In considering the comparative cost of mining, the following are some of the essential conditions determining the result which it is necessary to take into account.

1. Size and character of the ore deposit.

2. Method of mining, (a) open cast, (b) underground. If the latter, whether room-and-pillar system, caving, filling, timbering, or a combination of two or more. The proportion of the orebody extracted is an important consideration The system of breaking the ground, the layout of the mine, the method of handling the ore, drainage, etc, are determining factors.

3. Depth and longitudinal extent of the workings. Increase in depth increases the cost of hoisting and pumping; increase in longitudinal and lateral direction increases the cost of tramming.

4. Character and amount of necessary development work; *i e*, the work that must be done to discover and give access to the ore The amount of "dead work" that is required is one of the greatest causes of variation in the cost of mining.

5. Quantity of water to be raised from the mine and the depth from which it must be lifted.

6. Quantity of coal, dynamite, timber, steel, etc., consumed per ton of ore.

7. Wages of labor of various kinds and its quality.

8. Cost per ton of coal and its quality.

9. Cost per pound of dynamite (various grades).

10 Cost of timber per 1,000 ft., board measure.

11. Tons of ore mined per annum, tons of shipping product sorted out; tons of waste raised.

12. Supervision and administration.

The conditions which are most closely comparable are those of large orebodies, of which the whole, or nearly the whole, is extracted and sent to the mill, as, for example, those of Ducktown, in Tennessee; Flat River, in Missouri; Homestake, in South Dakota, and the copper mines of Lake Superior. In the case of narrower veins, like those of Cripple Creek, comparison can be made only by considering as the ore all the material that has to be taken out; but inasmuch as it is seldom profitable to take out more than enough to afford working room, the costs in such mines are necessarily higher than in those wherein large faces of ore can be worked in great chambers. The lowest cost of mining ought theoretically to be experienced in large deposits of ore that can be entirely extracted as suitable for milling or smelting, and can be opened by drifts of large size.

Considered commercially—and, after all, mining is simply a commercial business — the true cost of mining is $X - Y = A$, in which A is the maximum profit realizable from the mine, X the market value of the ore, and Y the cost of mining, including all outlay for plant and development work; but it is only in rare cases that advance estimates can be reduced to these elements. However, the cost of getting to the ore and the cost of plant for its extraction are certainly factors in the cost of mining; this leads to the much-discussed question as to how the expense for new construction, and great developments, like new shafts or adits, should be charged in annual statements of mining costs.

It should be recognized clearly that any useful comparison of costs can be made only in the light of analysis of all the determining conditions. The cost of mining at one place may be \$3 per ton and at another place only \$2, yet the better work may really be done at the former. In itemizing the various elements of cost, such as breaking ground, shoveling and tramming, explosives, timbering, pumping, etc., and comparing them, we shall arrive closer to the actual results, but we shall fail to get at the truth unless we consider the proportion of the orebody ultimately won and the final profit in its extraction. Mr. J. R. Finlay expresses

this principle so clearly in discussing the cost of mining at Cripple Creek, Col.,[1] that it is useful to repeat some of his remarks. He says: "A low cost per ton, either of crude rock hoisted or of sorted ore shipped, does not necessarily indicate either good mining or good management, and is nearly as apt to indicate the contrary. Two mines may be working in exactly the same kind of ore, and one may ship ore at more than twice the cost for mining that the other does, and yet be doing better work and making larger profits.

"At Cripple Creek the ore occurs in a multitude of small veins, either single or in aggregates. In the small seams which constitute either the vein itself or a component part of it, the ore is rich, but the rock on the walls, or between the seams, is either wholly or partly waste. The rich seams may vary in thickness from a mere crack to a foot or two; and for these widths, it may carry from one to several hundred ounces gold per ton.

"There are no large orebodies in Cripple Creek. It is doubtful if any single orebody, or even any single vein, has produced 100,000 tons of shipping ore. The largest and best veins have been found in the granite, where the rock-walls themselves are sometimes uniformly impregnated with value for a width of 30 or 40 ft. In such places large amounts of clean ore have been mined and shipped without sorting, but only in the swells; when the vein narrows down it is always necessary to break some waste in order to make room to work.

"The ore, therefore, is mined from veins of such a character that it is impossible to get it out without mixing with some worthless rock. The problem of handling this ore economically depends on the cost of treatment. This cost is at present—and is likely to be always—so high that it becomes very essential to throw out as much waste, or low-grade ore, as possible before shipping. Could the ore be treated for a dollar or two a ton, the proposition would be entirely different."

The ore shipped from Cripple Creek is a concentrate produced by hand sorting. Numerous mines in other districts are operated under similar conditions Even at Lake Superior a considerable proportion of barren and lean rock is sorted out of the rock hoisted, in order to effect a preliminary concentration of the ore before sending it to the stamp mills. This leads to a consideration of the point where mining leaves off and ore-dressing begins. Probably

[1] The Engineering and Mining Journal, November 21, 1903.

there will be no disagreement that sorting practiced on the surface is technically a process of ore-dressing, but sorting is also done underground, and while that might also be technically considered a process of ore-dressing, it would be highly impracticable in book-keeping to distinguish between it and mining.

These features indicate some of the difficulties in reducing the cost of mining under various conditions to any sound basis of comparison. Unquestionably, however, an analysis of the elements of cost would bring us nearer to such a basis, and an examination of the costs, as officially reported by various mining companies, will show the desirability of such an analysis. It is, for example, difficult for anyone not familiar with the special conditions to understand why the cost of extracting a ton of ore from a great, well-equipped mine like the Anaconda should be \$3 50 per ton, when ore is mined for \$2 per ton at Cripple Creek, Col. Anyone examining the reports of the Lake Superior copper companies is naturally led to inquire why the cost of mining in the Atlantic is only 90c. per ton, and in some other mines of the same district twice as much Another interesting question would naturally arise as to why mining can be done with insignificant equipment and so cheaply as it has been in the Joplin district of Missouri.

It is hoped that a discussion of these questions and others of the same character will be taken up in further contributions.

THE COST OF MINING

(February 23, 1905)

The Editor.

SIR—As Mr. Ingalls begins by saying in his recent article, the matter of the proper cost for mining is a hard subject to generalize, but I am of the impression that, if more companies published their costs in proper detail, the difficulty of generalization would be much less, because even in cases of wide difference of conditions, there would still be found operations in which the conditions were more or less parallel. I have amused myself in comparing certain items of cost at the Treadwell mine in Alaska, as published by Mr. Kinzie, and those of the Portland mine at Cripple Creek. At first glance one might say that in no two places could the conditions be more dissimilar—the Treadwell, with its immense bodies of uniform ore, mined very rapidly with comparatively small outlay for exploration and development, and the Portland, with its aggregate of more or less scattered and small orebodies requiring for exploitation a large amount of development work, done to a considerable extent at random. Nevertheless, I find that there are certain operations at the Portland that find a parallel in the Treadwell, and in these cases it is worth noting how well the Cripple Creek property will compare Mr. Kinzie gives the tonnage broken per machine shift in underground stopes of the Treadwell at 34.96. He does not state whether this is tonnage removed from the stopes or the actual tonnage broken, it being understood that in the underground part of the Treadwell mine about one-half of the ore broken is left in the stopes until they are worked through. In case the tonnage referred to is the actual breakage record of the machines, the performance is almost identical in cost with that in the wide stopes at the Portland mine. The table below gives the comparison.

At the Portland, small machines, 2¼ in., operated by one man at $4.00, are used; at the Treadwell, 3¼-in. machines, using 2.15

times as much air at the same piston speed as the Portland machines, and operated by two men at $7.87 per day.

	Portland	Treadwell
Tons per machine in all stopes	12 4	34 96
Tons in wide stopes	17 7[1]	[2]34.96
Tons per machine in drifts	5 3	9 6
Tons per foot in drifts	2 5	7
	Cents	Cents
Labor cost per ton on ore broken in large stopes	22 6	22 5
Labor cost per ton broken in drifts	75	82
Labor cost per foot of drift for machine drilling	1 86	5 75

[1] One-man machines [2] Two-men machines

In the above cases the comparison is not unfavorable to the Cripple Creek property, the development work being much cheaper at Cripple Creek than at the Treadwell, but in this particular the cases are not parallel. Development work in the Treadwell means large openings designed for the extraction of heavy tonnage. At Cripple Creek the primary object of development work is to discover ore, and consequently the drifting and cross-cutting are designed to be driven with the greatest speed and the least expense, regardless of the future utility of the work for mining purposes.

The result of this difference in design of development work shows in the cost of tramming, which is over 20c. per ton at the Portland, as against a trifle over 3c. at the Treadwell. Twenty cents per ton is about the least that the tramming can be done for in Cripple Creek under the present plan in mining operations. It is not practicable to introduce haulage systems underground on account of the small, scattered orebodies connected by crooked drifts. It is hard to see how any other arrangement than the present would apply. Therefore, the difference of cost of tramming between the Portland mine and the Treadwell is sufficiently accounted for by the radical difference of conditions.

Another expense at the Portland is timbering, which averaged for six months almost exactly 50c per ton. At the Treadwell this expense is practically zero. This is a point in which the practice at the Portland mine might be open to criticism, because other mines in Cripple Creek succeed in extracting their ore with almost as small expense for timber as the Treadwell. Nevertheless, as I

have attempted to point out in one or two former communications, the problem is not one of mere cost per ton, but that of mining the value at the least cost from a profit-making point of view, and in my judgment the timbering cost at the Portland is fully justified by the conditions.

Again, the cost of ore-sorting at the Portland is about three times as much as that of milling and concentrating at the Treadwell. Here again the difference of cost is justified by a difference of conditions so obvious as scarcely to merit discussion

The cost of hoisting at the Portland is about 22c. per ton, as against about 11c. for the Ready Bullion and Alaska Mexican, which handle about the same tonnage. This difference is one which should not exist, and is accounted for largely by the bad design of almost all Cripple Creek hoisting plants There is no reason why Cripple Creek ores should not be hoisted by skips and dumped directly into ore-bins, as is done at the Treadwell, thereby doing away with the expense of top-tramming, which in Cripple Creek is invariably a large item.

I am giving the above comparisons largely because they are interesting in themselves, and partly to show that if the proper details were given, there is a legitimate comparison that can be made between mines even of great apparent difference in character. The publication of costs would be of advantage to many, probably most, mining companies, because by so doing they would bring to light certain deficiencies in their own management, which would, in course of time, be pointed out to them Many companies are deluded into thinking that their superintendents are good mining men, simply because they have been on the property a long time.

Taken in the large, the discussion of mining costs will merge into that provoked by Mr. Hoover's article on mine equipment and ore-reserves Most competent mine managers will probably agree with Mr. Hoover that the problem is, to extract and market the entire deposit constituting a mine at the greatest profit to the stockholder They will fully agree with him on the economy, not only of providing abundant equipment for the rather speedy working of visible ore supplies, but also of working that equipment to its utmost capacity. The consideration of such subjects is the consideration of mining costs in the widest sense. The problem of deciding upon the best methods, the proper scale of operations and the *most desirable* cost to be aimed at, is one big enough for the

best business intelligence a mining engineer can muster. Unfortunately, too many engineers confine their attention too much to technical subjects, and the owners of large enterprises often find it necessary to leave them out of consideration in the decision of the broader aspects of the business.

Ability to see things in their proper proportions and to lay strong hold of the essential features of an enterprise are more vital to the success of a manager than all other qualities combined, and are more necessary at the beginning of an enterprise than at any other time. It is, indeed, rare that a good mine is absolutely spoiled, but nothing is more common than to see mines worked out under such handicaps of bad management that they fall enormously short of producing their just profits. This bad management is just as apt to be the result of some mistake in general principles, such as methods of mining, design and scope of plant, as from failure to work out everyday details. Mistakes due to failure to comprehend the structure and capabilities of the ore-bodies are extremely common, and I have seen mines brought to the verge of ruin by such mistakes.

It is only when the salient features of an enterprise have been worked out and decided on, that one is justified in figuring on the details of cost. For instance, one can scarcely estimate how much it will cost to hoist a ton of rock until he knows what kind of an engine he is going to have, as well as the appliances used in loading and dumping, etc. If his tonnage is small and uncertain, he will probably prefer not to put in skips with underground loading-pockets, but will use light engines, small cages or buckets. Thereby he will save a portion of his plant investment at the expense of a higher cost in daily manipulation. If you are able to hoist only 40 tons a day, you will still be compelled to employ two engineers at $4 a day, and your hoisting will cost 20c. a ton for engineers' labor alone. Circumstances may be such that a hoisting cost of 40c a ton will be just as good practice at one place as 4c. a ton at another place. The thoroughly competent engineer will see the folly of working on unjustifiable economies. If a man really expects to hoist only 10,000 tons altogether, he will be a better engineer to get all that rock out with a windlass at $1 a ton than to buy a $10,000 hoist in order to get it up for 10c. a ton.

The same kind of reasoning applies, in many ways, to a variety of items that make up mining costs. For example, a man may be

doing excellent drifting, but he may do so much of it that it may appear as a large item in his cost of ore. Very likely he ought to receive praise for his good drifting, instead of blame for his high cost per ton.

It seems to me, therefore, that the costs that afford most interesting comparisons and are most easy to obtain, are those which apply to such things as drifting, shaft-sinking, shoveling, machine drilling, etc., etc ; in fact, just such details as Mr. Kinzie gives in his paper on the Treadwell. When costs on these things are correctly stated, with information regarding the conditions of working (such as ventilation, water, kind of rock, manner and method of working), they become valuable. It would probably be amazing to see the difference between mines in the same district, working under identical conditions. These costs, therefore, and not the total costs, are those that might be given publicity without harm to the mining companies, and more often to their great advantage

J. R. FINLAY.

Colorado Springs, Feb. 19, 1905

MINE RESERVES

(March 2, 1905)

The Editor

SIR—When I wrote you, early last year, asking for an expression of opinion as to the wisdom of the practice of keeping a reserve of gold or bullion at a mine, it was because I had a premonition that the question would have to be settled in Western Australia sooner or later. The Boulder Perseverance scandal has brought the matter to a head in that State, just as the matter had been fought out earlier in the smaller companies in Victoria. When writing to you, the point that was put was that the practice was bad, inherently bad, inasmuch as it gave great opening for fraud. Nothing has occurred to shake that opinion.

If the evidence of the leading Kalgoorlie mine managers, given before the Boulder Perseverance Commission, in favor of the retaining of a reserve at the mine, is analyzed, it will be found that the chief reason adduced in support is that the share market must be kept level by having level yields. The members of the royal commission were so impressed by this contention that in their finding they adopt the views put forward by the mine managers. Still, is it in any sense the duty of the mine manager to consider the share market? If he does, is there not always the risk that he will take a hand in it? With men receiving the regal salaries earned by the managers of the big Kalgoorlie mines, there ought not to be any temptation to go astray by using the knowledge they obtain in their official position to speculate in their company's shares. But the history of Kalgoorlie mining is such as to enforce the conviction that, not only have wrong estimates of the value of the ore been given, but also that bullion reserves have been used to assist in market operations. With smaller companies, where salaries are low, how much greater must be the temptation to men to try to make themselves financially secure by manipulating the bullion reserve. But does the existence of a gold reserve protect shares from fluctuations? Victorian experience says No. The

grade of the ore falls off and the yield is kept up by the assistance of the gold reserve. No one, ostensibly, knows of the true state of affairs, except the manager and the directors—when the latter are kept posted as to the reserve—or the manager alone, and perhaps one of his trusted officials. Yet the market soon shows signs that something is wrong, although the yields have kept up to their average. Some one invariably learns of the changed circumstances of the property, and he gets rich at the expense of others. Is this good for the industry? It may be said that a study of the assay plans will convey the fact of the falling off in the grade of ore. But we in Victoria do not have assay plans, and even if we had, the ordinary shareholder, like the mine manager, hopes that pay-dirt may again be entered. As it is, however, the practice of keeping gold reserves has been practically abandoned here. And it is an answer to those who think that stocks would depreciate if yields were to fluctuate, that some of the most stable shares in the bullion market are those where no gold reserve is maintained. Shareholders are educated to know that they must expect variations in yield All they want to be told is, that the mine is opened up well ahead of the picks, and that the average value of the dirt is maintained. Then they are not alarmed by poor patches.

One point touched upon in the evidence given before the royal commission deserves attention. Managers stated that they would not tell a shareholder the amount of the reserve if he made an inquiry on the point The Victorian Companies Act provides that in a mining company a shareholder or a creditor can demand, and must be supplied with, three months' accounts from the board Just see the position the directors would be in if, while telling that the debts were so much and the assets so much, they omitted to state that there were so many ounces of gold held in reserve. Should the shareholder sell on the statement and the scrip rise, he could recover against them for furnishing a false return. If he held, and shares declined, he would still be in the same strong position. It is the duty of the directors to know if a gold reserve exists, and still more is it their duty to know how it is used. With this information in their hands, they have no right to refuse to tell a partner—that is, a fellow shareholder—how the reserve stands.

Only under certain conditions can a gold reserve at a mine owned by a company be justified. (1) That it shall be kept with the full knowledge and consent of the shareholders. (2) That

every monthly yield shall be recorded truthfully—say, 10,000 tons for 8,250 oz.; taken from reserve, 1,750 oz.; total return, 10,000 oz., if the average to be kept up is an ounce. (3) That the extent of the reserve then started shall be disclosed; and (4) that every month the withdrawals from it, or the additions to it, shall be stated. Then the ordinary shareholder will know how he stands, and as he is the backbone of the industry, it is to everyone's interest that he shall not be deceived, and so be led to withdraw his support from it.

F. H. BATHURST.

Melbourne, Victoria, Jan. 21, 1905.

THE COST OF MINING

(March 9, 1905)

The Editor

SIR—Mr. Ingalls' timely article on the above subject calls attention, not only to the desirability of uniform methods of keeping mine costs, but also to the publication of itemized statements of costs. On the latter point there is much difference of opinion.

There should be no difference of opinion regarding which enters into the cost of mining. Nothing short of the total cost can be correct, and anything less is, to say the least, misleading. No matter how the costs may be divided up or distributed, the net profit per ton deducted from the market value equals the cost of mining, or, as Mr. Ingalls puts it, $X - Y = A$.

The tabulated costs quoted by Mr. Ingalls, and admitted imperfect, are simply *ex parte* statements. No charge is shown for maintenance of plant, taxes, insurance and many other items of substantial expense inseparable from ordinary mining operations.

Here is a more complete statement, taken from the balance sheet of another Cripple Creek property (*Mining Reporter*, December 8, 1904), and which, I presume, represents English methods:

COST FOR YEAR ENDING JUNE 30, 1904

Blocking out ore, etc.	$4 131
Ore breaking.	5 182
Timbering	0 744
Pumping	0 933
Hoisting and tramming	1 469
Ore sorting and loading	0.608
General lighting	0.112
Surveying	0.080
Mine sampling	0.066
Wages of foreman, etc	0.265
Watchman	0.134
	$13.7240

Cost for Year Ending June 30, 1904 (Continued)

Repairs and improvements to buildings and plants	$0 2896
Shipping and selling ore, sampling and assaying	0 1793
Salaries of consulting engineer and manager	0 8923
Salaries of clerks	0 0323
Auditing fees and expenses	0 0244
Assay plans	0 0364
Traveling expenses	0 0050
Exploitation expenses	0 0770
Insurance	0.1494
Taxes (less adjustment)	0 1693
Compensation, etc , cage accidents	0.2502
Strike expenses	0.0875
Legal expenses	0.0252
Loss on cottages	0.0110
Miscellaneous	0 0730
Total	$2 310
Freight and treatment on 43,758 tons	$7 743
London office expenses, including $5,178.80 for a special report on the mine	0 513
Total cost	$24.290

A good system of cost keeping, not necessarily an elaborate one, is an essential requirement of any well-managed mine, nevertheless it is very often, through faulty methods or tediously minute classifications, a matter of considerable expense. When the ordinary shift bosses are overloaded with cost keeping or cost distribution methods the general work suffers, and the cost of breaking rock goes up, as it were, in an effort to keep it down. In other words, while the foremen or bosses are endeavoring to find out how many nails, caps and candles are consumed in breaking a ton of rock in one stope, the men may be idling in another.

The minute elaboration of mine costs is largely academic—the result, perhaps, of autocratic mine management with fledgelings instead of experienced birds in charge of the operations. The autocrat, seated in his office chair at some financial center, in his endeavor to direct the operation of some score or more mines, often attaches undue importance to mere items of cost (which are seldom strictly comparable for any two mines) and pays little if any attention to the practical mining ability of those in charge of the operations Should not the ability to discover ore, or even not to lose it, when discovered, rank fully as high as mere cost of production? The most elaborate cost system ever devised will never successfully displace mining skill acquired by years of close, intelligent observa-

tion and experience in actual mining work. I have known mines where the cost of producing and milling or marketing a ton of ore was steadily lowered by one expedient or another, but somehow, before the total cost reached a minus quantity profits vanished, the stockholders kicked, or something else happened, a strike, like as not, and the mine was eventually leased, with results entirely satisfactory to the stockholders.

We have, here in Colorado, scores of cases where lessees (practical and experienced miners) have taken up unprofitable and practically abandoned mines, made them pay handsomely, and turned them over at the expiration of their leases in condition where even the Rodomont autocrat could for some time work them profitably from his observation point, perhaps thousands of miles distant from the field of operation Now, lessees do not depend on any elaboration of mining costs to secure these results, but rely almost entirely on their ability as miners and on their practical experience, which has taught them that mining *is the art of making money from ore deposits*; that the cost per ton is only one factor; and that breaking the ore as free as possible from waste, and properly sorting it, is often of more importance, for the reason that, while it increases the cost of raising a ton of ore, it also increases the net profit of the operation, which should be the objective point in mining. Therefore, I hold, the successful miner in any given mine is *he who returns the largest percentage of profit from the gross value of the ore*, not necessarily the one who can show the lowest mining cost. To reach this desirable condition, the cost of milling or smelting must be studied, together with the cost of the actual mining and sorting or dressing of the ore; hence these charges, very properly grouped separately in the itemized costs, are brought together to form the total mining cost as previously defined.

I favor a simple system of cost keeping, where the distribution of supplies, etc., is made direct from the mine store, on the orders of the superintendent or shift bosses, and they are charged at once to the particular place or work indicated.

The general subdivisions of mine costs that suggest themselves are: (1) Winning (blocking out ore), (2) stoping the ore, (3) dressing or milling or smelting the ore, the sum of these being the entire cost of producing and disposing of one ton of ore, provided always, the amount won during the period under review equals the amount of ore stoped, otherwise corrections must be made for in-

creased or decreased ore-reserves; or, at least, the condition of the ore-reserves should be clearly stated. The average stockholder is satisfied with the totals as above, together with the value of the ore and profit per ton, or the usual balance sheet and profit and loss statement. Then why bewilder him with itemized statements of costs? Useful and indispensable though they may be to the management, they are as invariably useless to stockholders.

The matter of publishing itemized mining costs is one that mining companies do not, as a rule, approve. As the president of a large company once said to me, "It is our private business, and why should we give it to the world to satisfy the curious, or help educate young mining engineers who have not had practical experience along those lines, or to furnish ammunition for the stockholders to make erroneous comparisons between two mines of perhaps very different type?" Throughout the Rocky Mountain region the average mining companies have dealings with the railways and smelters in marketing their ores, and, rightly or wrongly, very often believe that these corporations are anxious to secure as high a tariff as they believe the ore will stand; and so, in places as far apart as British Columbia and the San Juan, and once in Old Mexico, I have at various times heard mine-owners say something like this: "Why should we publish the itemized costs of producing a ton of marketable ore? Neither the railroads nor the smelters publish itemized costs for hauling or for smelting a ton of ore, and, furthermore, we do not believe that it costs the railway corporations any more to haul a ton of $50 ore than it would to move a ton of $15 ore over the same distance, and yet the charge is often double. And so with the smelters, the charges on some ores are based simply on their precious metal value."

A full discussion of the various methods of classifying mine costs may, and I hope will, result in the gradual adoption of a uniform system, from which tentative comparisons can readily be made between mines of similar type, etc.; but under the present economic conditions that obtain in the West, the great majority of mining companies will, as now, refrain from publishing itemized statements of costs.

PHILIP ARGALL.

Denver, December 12, 1904.

THE COST OF MINING

(March 23, 1905)

The Editor

SIR—The scope of such a discussion is necessarily wide, but in the following I shall confine myself to certain fundamentals, rather than to a comparison of examples. An intelligent study of mining costs must be preceded by an analysis of the various items going to make up the total, in order to obtain a segregation that shall be logical and useful. Such items as Mr. Ingalls gives in his brief tabulation are certainly useful, but they do not yield the whole, or even the larger part, of the value that the figures in themselves contain. This, I understand, Mr. Ingalls recognizes, and I have no doubt that he will fully indorse the statement that a classification in this form may conceal details of the first importance to the engineer.

In the first place, it is pertinent to inquire, What are the uses to which accounting lends itself? There is the obvious use of supplying a business need; of giving to the stockholders, present and prospective, a reliable idea of what the property can do in the way of profits; and, in general, how it is managed, though it must be admitted that comparisons of cost in this way may be misleading In fact, they are chiefly valuable in raising inquiries that only a more logical segregation can answer. These commercial accounts will naturally fall under obvious and simple heads, presenting what would be, from the engineer's point of view, mere summaries of the more extended subdivisions which are technically useful; and it is the logical basis for these technical accounts which particularly concerns this discussion.

This basis may be simply a cutting of expenditure into small items, as is the case in Mr. Ingalls' table. Frequently this is all that is done, and the valuable information afforded is considered the end of the business. But there is more to be gained than these figures directly give; and, with this fact in view, it is worth considering what it is for which the engineer really has use. As

manager, he wishes to compare his accounts, month by month and year by year, both with themselves and also with those of other mines, as a check upon operation and for suggestion of improvement; so far as this goes, the items, as given herewith, answer fairly. But he wishes also to know how costs will be altered by change in tonnage. This is a matter of importance, for the mine manager as well as for the examining engineer; it is imperfectly given by such a system, except for those divisions which are direct functions of tonnage. Some accounts are not functions of tonnage at all, such as superintendence, offices and taxes; others are not proportional functions, such as pumping, hoisting; there is a long list of such accounts.

Then both the manager and the examining engineer need a division; this should recognize accounts: (A) that are independent of, and (B) those that are dependent on, tonnage; that is, (A) where the totals for a period do not alter with variation in tonnage, and (B) where they do so alter. Further, under (A) there are some (A1) accounts that are practically constant, such as superintendence and management, and others (A2) that, while independent of tonnage, are variable, such as those that alter with change of season, traveling expense, etc. In close estimates it will help to have these known separately. (B) also has two natural subdivisions: (B1) where totals are virtually direct functions of tonnage, and (B2) where totals are indirect functions of tonnage; that is, they alter with tonnage, but not proportionately. Examples of (B1) are "stoping" and "tramming"; (B) includes development, which varies according to conditions of mine and orebodies; also certain repairs.

There is another large class of accounts, namely, those additions to plant, equipment and repairs that will make themselves felt over extended periods; in other words, "capital expenditures." These should be redeemed by charges against operating expenses over varying periods. Whatever may be the business policy of charging these off, there can be small question that the accurate logical treatment for the engineer is to consider them as a part of his operating expense, month by month. No estimate of cost which roughly assumes that such expenditures will equalize themselves will be fair; if they are not put into "working cost" there is always the danger that they will be overlooked entirely in making estimates. A division of expenditure on these lines can be carried out

to any extent of itemization, and will give a system of technical accounts that will furnish all the data desired.

In studying the problem of a proper segregation, it will be seen that none of the advantages of the more common systems of plain subdivision will be lost; the basis is applicable to the smallest as well as to the largest mines; the degree of subdivision can be extended, as easily as in any other system, to any degree of minuteness demanded.

In the foregoing I have aimed to outline a familiar principle; it is so well established that a large part of the recent discussion in this JOURNAL on "Mine Equipment and Ore-Reserves" hinges upon it. However, though the principle is not new in practice, so far as I know, before the discussion referred to, it had not been brought out in print.

R. GILMAN BROWN.

San Francisco, March 1, 1905.

THE COST OF MINING

(April 6, 1905)

The Editor.

SIR—In proposing this intricate subject, Mr. Ingalls has paved the way for an almost unlimited interchange of ideas upon an important, but neglected, branch of mining As Mr. Finlay has so well put it, "The problem of deciding upon the best methods, the proper scale of operations and the most desirable working cost to be aimed at, is one big enough for the best business intelligence that a mining engineer can muster."

The subject involves a phase of mining concerning which not alone the newly graduated mining engineer lacks knowledge, it includes problems and conditions which many engineers of long experience have not had the good fortune to encounter To obtain reliable and well-segregated figures pertaining to working costs from the average mine, this is one of the most difficult tasks which the engineer can undertake; unlike the other factors that contribute to mine valuation, the necessary data can be obtained only from written records.

I cannot understand why so many mining companies continue to practice such wasteful brevity. It is a fact that, in most cases where such method is practiced, not only the officers of the company, but their servants also, unconsciously fail in possessing and preserving an adequate knowledge of their true conditions. In estimating the value of a mine it is impossible to separate this factor of "working cost"; nevertheless, we often read mining reports in which the author may have accurately applied every known principle in estimating the ore-reserves, and yet, for want of proper data, he may decline to hazard an estimate of the working costs. The working cost is to mine valuation, what width is to the assay-value of a given vein

It does not appear to be a difficult task to standardize the headings to be used in the final classification of mining costs, such as mining, tramming, hoisting, sorting, crushing, and so on, following

the different processes used in the treatment of the ore; but to settle upon a uniform method of segregating the items contributing to these accounts, and a correct distribution of the moneys expended, this is a subject which should elicit information both interesting and instructive For, no matter what the system of time-keeping may be (within economic limits), there are certain moneys which must be distributed without the assistance of detailed record.

Working costs will continue to show variations, in the same districts, under the same conditions of vein-width, capacity, etc., because engineers, like other people, differ in their views of application; but, nevertheless, there are certain fundamental principles to be observed. If uniformity is regarded in mine statements (which reflect the local conditions), a desire to effect legitimate economy will be created, and inferior methods will soon be eliminated. As a concrete example, in illustration of the methods sometimes applied in the segregation of accounts, where milling and cyanidation only are employed, the following will serve; the final summary is given first, in order to elucidate some points more clearly:

SUMMARY

	Total Cost	Cost Per Ton	Percentage
Mining	$128,787 68	$3 38	45.54
Transport of ore	3,857 18	0.10	1 36
Sorting and crushing	8,625 31	0.22	3.00
Milling	38,963.87	1 02	12.00
Cyanidation.	34,586 34	0 90	0.12
Gold realization	4,013 80	0.10	1.42
General charges	22,037 60	0 57	7.8
Office expenses	9,367 60	0.24	3.32
Development redemption (Depreciation?)	32,451.93	0.84	11 4
Totals	$282,691.31	$7.42	

In order to make the above summary valuable, and comparison possible, it is necessary to know what contributes to the several accounts This is shown, in case of "mining," for example, to be as follows:

MINING

	Total Cost	Cost Per Ton	Percentage
Salaries	$4,462 88	$0 116	3.49
Wages (skilled)	12,018 84	0 315	9 34
Contractors	10,132.88	0 266	7 89
Wages (unskilled)	26,751 86	0 700	20.78
Food	10,889.82	0 280	8 49
Stores	3,719.11	0 096	2 88
Explosives	12,229.29	0 320	9.49
Charcoal.	41.46	0 001	0.03
Fuel (timber)	475.75	0 012	0 39
Maintenance	2,590.76	0 066	2 00
Workshops	817.74	0 021	0 63
Transport	235.63	0 006	0 18
Hospital	539 76	0 014	0 42
Labor premiums	220 67	0.006	0.19
Pumping	10,867 76	0.288	8 44
Compound expenses	3,620.68	0.090	2.8
Compressor charges	633 08	0 016	0 49
Manufacturing and sharpening hand drills	8,489 17	0.220	6.59
Hoisting	5,702.11	0.148	4.42
Underground tramming	13,040 95	0 338	10 05
Assaying	986.14	0 026	0 76
Surveying and sampling	321.31	0 008	0 25
Totals	$128,787 68	$3.38	

A number of the accounts given herewith, such as maintenance, pumping, underground tramming, manufacturing and sharpening drills, require again to be subdivided, because they in turn contain important factors; with all this the question arises: To what extent does it pay to segregate mining accounts? The remaining items —stores, wages, salaries, fuel, etc.—carry us back to the timekeeper's and the storeman's records. It appears to me that with the details as given herewith, when accompanied by a correct distribution and a knowledge of the local conditions, the engineer should be fortified with material sufficient to direct the work effectively and to compile reliable forecasts.

Probably one of the most troublesome accounts to deal with, especially in cases where the shares are quoted on the market, is "development," to which is charged the money expended in opening up the ore-bearing ground, before and after the reduction of ore has begun. The common interpretation of the term makes it include all operations (such as driving, cross-cutting, sinking—

exclusive of main shafts—raising, hauling, sampling, assaying, surveying and handling the barren ground) which result in the opening up of ore.

Up to the time when milling begins, we will assume that $50,000 has been expended upon development work, and it is estimated that 100,000 tons of ore have been developed, hence an obligation of 0.5c. per ton has been created; but a part of this money has contributed toward the partial exposure of other tonnage, which, however, cannot be accurately estimated. In order to arrive at the cost per ton of the developed ore, the measurements taken underground are used, while the money spent is redeemed upon the basis of the tons milled. These two figures seldom, if ever, agree; and, while the sorted product will account for a part of the discrepancy, there are always large differences between the tonnages as measured underground and the combined total of tons milled and sorted.

In addition to this consideration, there are monthly expenditures on account of development work. The cost of development per ton over any period, as one month, depends upon the width of the vein encountered, the relative position of orebodies, labor conditions, etc., during that period; thus, if development costs are charged to the current-month expense, wild fluctuation will occur in the working costs. Such irregularities create a feeling of uncertainty, which might be followed by forced sales of the shares and consequent depreciation, a result not tolerated in some mining centers.

Before the reduction of ore has begun, the cost of developing a certain tonnage is far greater than at any other period, because administration and other constant charges must be wholly carried by this account; hence it seems only fair that certain adjustments should be made in redeeming this expenditure, otherwise the present shareholders become unduly taxed for the benefit of future holders. In some instances the expenditure, on account of development up to the time milling begins, is charged to "capital account," and written off in the same manner as machinery, reservoirs, or other permanent equipment; in such a case only the current-month expense is charged to working costs.

Another method of discharging this obligation is by creating a "suspense account," by charging the development expenses to the reduction stage, and the excess development for each month

thereafter to this account. Then a fixed charge is made monthly for development, and the "suspense" account is written off in annual sums, which are measured by the work of the previous year. This method seems to give satisfactory results.

It is desirable that the methods of distribution be reflected in a statement of working costs, accompanied by the application of certain definite principles. "Capital" account is generally elastic and often much abused. The items usually charged to this, such as machinery and plant, buildings, main shafts, etc, are supposed to cover expenditures on permanent work and equipment. If the conditions are such that the life of the enterprise can be calculated accurately, the treatment of this account is simple, and the capital can be amortized at a certain computed rate of interest. If this account be not embodied in a statement of working costs, nor referred to therein, effective work in mine equipment is not reflected. Hence, for this and for other less weighty reasons, it would seem important that a certain life be assumed, or other measures taken whereby the moneys might be redeemed upon a fixed basis, without creating an unduly heavy charge.

A discussion that will conduce toward standardization of mining costs, as well as toward method in other departments, will prove of invaluable service, both to the engineer and the investor.

F. C. ROBERTS.

Berkeley, Cal, March 7, 1905.

COST OF CHLORINATING CRIPPLE CREEK ORES

BY PHILIP ARGALL

(April 27, 1905)

THE special report on the operations of the Portland mine and mill during the year 1904, recently issued by the president of the Portland Gold Mining Company, gives us, for the first time, an opportunity of analyzing and estimating the total cost of chlorinating Cripple Creek ore in a modern mill.

During the year under review, the Portland Gold Mining Company treated in its Colorado City mill 88,997.44 tons of ore, averaging $24.257 per ton. The mill was credited with earning a treatment charge of $623,253.03 in handling this ore, which amounts to $7.003 per ton; the profit on the year's operation of the mill is said to be $153,833.73, or $1.7285 per ton treated; by deducting the latter amount from the treatment charge, we find the cost of milling a ton of ore, including metal loss, is $5.2745. There is a heading "loss by extraction," and that must mean metal loss, $105,951.41, which amounts to $1.1905 per ton treated, from which it appears that the book cost of chlorinating a ton of ore during the past year was $4.084, exclusive of amortization and interest on the capital used in the business. The method of keeping the accounts is somewhat peculiar, and evidently designed to compare the result of milling the Portland ore in the Portland mill, against selling the ore to the custom mills; this, at least, would account for the peculiar system of allowing the mill $7 per ton for treating the ore, and I shall try to make this comparison.

Turning to the treasurer's balance sheet, it is possible to trace out pretty closely the items of the above cost, but I make it very nearly 10c. per ton more, which would be almost balanced by the "treating concentrates" item, or there may be some credit not apparent on the balance sheet that offsets this extra 10 cents.

	Total expense	Cost per ton
Bullion expense	$7,600 86	$0 0855
Treating concentrates	8,363.92	0 0938
Operating account	125,675 27	1 4121
Chemicals.	69,451 63	0 7804
Assay supplies	5,362 21	0 0602
Store-room account	43,675 18	0 4907
Fuel (roasting and drying only)	38,835.48	0.4285
Power (electric)	26,395 92	0.2966
General expenses	12,150.95	0 1367
Legal expenses	10,763 51	0 1209
Office expenses	6,690 07	0 0752
Office furniture (fixtures)	890 38	0.0100
Repairs.	442 90	0 0050
Treating by-products	16,493.20	0.1853
88,997 44 tons @ $4 1809 =	$372,091 48	or $4 1809

In addition to the foregoing amounts there is a charge of $27,079.59 to "equipment" and $33,560.76 to "construction."

As the mill has been in operation several years it is difficult to understand the further charge for equipment, in addition to a heavy construction charge; in the matter of repairs, however, the palm is conceded to the Portland mill, unless perchance the cost of repairs is hidden in the "storehouse" and operating accounts.

To compare intelligently the above costs with the rates charged for treating ore by the custom chlorination mills, we must include amortization and the capital involved in the business. It is well known that the custom mills pay for the ore as it is sampled, and carry a large stock of ore on hand, usually a month's run. Therefore, we must charge to the Portland mill the interest on the capital locked up in ore, bullion, stores, etc., and I shall assume the following:

Ore, 3,000 tons	$50,000
Store.	30,000
Bullion and gold in solution, etc.	40,000
Working capital	30,000
Total	$150,000

This at 8% will equal 0.135c. per ton of ore treated. Summarizing these figures we have the following:

Cost of chlorinating (book cost)	$4 084
Interest on capital invested in the business	0 135
Amortization, say	0 781
Metal loss	1 190
Total	$6 190

It would appear that the gold in the ore is billed to the Portland mill at $20 per oz. (the price paid by the custom mills), less $7 per ton treatment charge, so we are now in position to make a fair comparison between the Portland mill and the custom mills in the matter of total cost of chlorinating Cripple Creek ore. As noted in this JOURNAL for December 29, 1904, p. 1022, the rate charged by the custom mills on ore varying from 1.25 to 1.5 oz. of gold is $7.75 per ton, less $1 per ton on long-time contracts, so on the latter basis ($6.75) it cannot be said that the charge of the custom chlorination mills is too high; they have a large amount of capital invested in their plants and are entitled to a good interest on the investment, considering the ephemeral nature of the business they are engaged in.

I am pleased to see continued improvements in the chlorination process, as shown in the following extract from the report of the superintendent of the Portland mill: "We have inaugurated a system of saving the values in wash-water from the barrels, which has heretofore run down the creek, and now saves the company thousands of dollars each year."

COST OF MINING AND MILLING

By R. J. Grant

(April 27, 1905)

The detailed expenditure to be discussed refers to operations at the Cosmopolitan mine, situated at Kookynie, in Western Australia. The figures are those for September, 1904. It should be added that the Cosmopolitan is about 500 miles from the coast, and 120 miles northeast from Kalgoorlie, on the government railway.

It is one of the many companies in Western Australia under the management of Messrs. Bewick, Moreing & Company. It was taken over by them in the latter part of 1902, with H. A Shipman as mine manager. At that time the costs were about $6.75 per ton for mining and milling. When Mr. Shipman left, in May, 1904, the costs had been reduced to $2.95. The writer succeeded Mr. Shipman. George Gill is underground superintendent, and Alfred Bloomfield is mill superintendent.

The conditions are not all that might be desired for low costs; the labor question is a serious one, and wages are high for the class of workmen employed. The average wage per eight-hour shift is about $3.20; this includes all classes, from $2.85 per shift paid to truckers and shovelers, which is the lowest rate, to $4 per shift for machine men working in wet ground, being the highest rate. Both machine men get the same rate; in other words, no helper is recognized.

Supplies are all high, explosives costing 50% more than in America, and other goods in proportion. Wood is used for fuel, and costs about $5.60 per cord, two cords being equal to one ton of average coal. Mine water, which is salt and contains 1% solid matter, is used for steaming and is a constant expense. The cost of cleaning boilers alone is over $300 per month.

The ore, or "stone," as it is called, is a glassy white quartz, carrying a small amount of iron pyrite, and, at present, about 7 dwt. gold per ton. The "reef" lies at an angle of 41° between hard granite walls, and averages 8 ft. in width, occasionally carry-

ing from 1 to 4 ft of waste in the center All ore in the stopes has to be shoveled, owing to the flatness of the foot-wall. For the month under report, the ore came from the 700, 800 and 900-ft. levels—but chiefly from the 900-ft level. The ore is trucked from the stopes to bins at the shaft, and hoisted from there in skips, holding about 2½ tons each, to the surface, where it is dumped into bins. It is run by gravity over grizzlies into Blake crushers set to 1½ in It is then hoisted 50 ft. and trucked to the mill bins. The mill contains 50 stamps, each weighing, when newly shod, 1,090 lb. The drop is 8 in., and the speed averages 106 drops per minute. The screens used are 20-mesh wire-cloth, and the height of discharge is from ½ to 2½ in. The pulp goes from the stamps over copper plates, 12 ft. long, then over 10 Wilfley tables to a tailing wheel, where it is elevated 50 ft. and run into leaching vats, which are fitted with distributors; here the sand settles, and is treated with cyanide. The sand residue is carried, by trucking and hoisting, to a dump 60 ft. high. The slime runs back to spitzkasten, where it is settled; then it passes into agitation vats and is treated with a 0 07% cyanide solution, and filter-pressed; the overflow water is run back to the battery and used again. The residue is trucked to a mixer, where water is added, and afterward pumped to a dam.

The mining and milling costs include everything except the London office expenditure, and cover taxes, insurance, general manager's salary, etc. All development work in the mine is done on contract at the following average prices: Drifts, $10; cross-cuts, $12.50; raises, $8.20 per ft. The contractor provides all explosives and candles, and delivers the ore into the bins at the main shaft, the company furnishing drills, tools and power

Precipitation takes place in ordinary zinc boxes; the clean-up is effected by the acid method. The roasting and smelting are done in the usual manner.

The gold is extracted as follows:

Amalgamation (boxes and plates)	61 55%
Concentrate by cyanidation	8 50 "
Sand by cyanidation	14 50 "
Slime by cyanidation and filter-pressing	6 00 "
Total extraction	90 55 "
Average value of "heads" for month	6 dwt. 18 gr.
Average value of "residues" for month	0 " 15 "

The cost of mining was as follows:

	Per ton mined.
Labor and salaries	$0 48
Explosives.	0.1050
Candles	0 0125
Steel	0 0705
Sundry supplies	0 0610
Power for machine drills	0.1300
Assaying and sampling	0 0165
Repairs and maintenance	0.0430
General expenses	0 0575
Proportion pumping	0 1225
Trucking and hoisting ore	0.2350
Timbering and filling stopes	0 1300
9,193 tons	$1 3555

The cost of milling is given in the table below:

	Per ton milled.
Rock-breaking	$0.0382
Ore transport, from crushers to mill-bins	0.0618
Battery and plates	0 4062
Concentrating	0 0340
Cyaniding concentrate	0 0236
Cyaniding sand by percolation	0.2254
Cyaniding slime by agitation	0 0886
Filter-pressing slime	0.0776
Precipitation and smelting	0 0698
Disposal of residue	0 1778
9,193 tons.	$1.2030

The working cost per actual ton treated was as follows:

Milling (9,193 *tons*)

	Per ton milled.
Labor and salaries	$0.0906
Power	0 1750
Repairs and maintenance.	0.0544
Assaying and sampling.	0.0072
General expenses.	0.0108
Quicksilver	0.0070
Shoes and dies	0 0358
Sundry supplies	0.0254
Total cost.	$0.4062

Concentrating (157 *tons saved*)

	Per ton treated.
Labor and salaries	$1.2194
Power	0.4266
Repairs and maintenance.	0.1318
General expenses	0.1466
Sundry supplies	0.0654
Total cost	$1.9898

Cyaniding Concentrate (162 *tons treated*)

	Per ton treated.
Labor and salaries	$0 4286
Power	0.0566
Assaying	0.0324
General expenses.	0.0496
Potassium cyanide	0.7692
Total cost	$1 3364

Cyaniding Sand by Percolation (6,768 *tons*)

	Per ton treated.
Labor and salaries	$0 0498
Power.	0 0724
Repairs and maintenance.	0 0428
Assaying.	0 0064
General expenses	0.0060
Potassium cyanide.	0.0936
Sundry supplies	0.0024
Total cost.	$0 2734

Cyaniding Slime by Agitation (1,456 *tons*)

	Per ton treated
Labor and salaries	$0 0906
Power	0 0308
Repairs and maintenance	0 0530
Assaying	0 0218
General expenses	0 0106
Potassium cyanide	0.3294
Sundry supplies	0 0222
Total cost	$0 5584

Filter-pressing Slime (1,456 *tons*)

	Per ton treated.
Labor and salaries	$0.3488
Power.	0 0206
Repairs and maintenance	0 0362
General expenses.	0 0418
Filter-cloth.	0.0336
Sundry supplies.	0 0092
Total cost.	$0.4902

Precipitation and Smelting (9,193 *tons*)

	Per ton treated.
Labor and salaries	$0.0204
Repairs and maintenance	0.0022
Assaying	0 0050
General expenses.	0 0024
Fuel..	0.0046
Zinc shavings	0 0138
Sulphuric acid.	0.0126
Sundry supplies	0.0088
Total cost	$0.0698

HOIST BY HIS OWN PETARD

(Editorial, April 27, 1905)

A SPASM of exactitude has swept across the mining world; "ore-reserves" has become a term of dreaded import; the young men have armed themselves with a boomerang and the old hands have been astonished into silence. The campaign for method in sampling, for conscience in estimating, and for science in final appraisal of mines has succeeded beyond our expectation. Transmission of ideas has been helped by the technical literature of the profession, and now, like the undertow that meets the oncoming surf, we are receiving the backward wave of a discussion that has spent its force for good. We are threatened with virtues that have been exaggerated to vices, and with methods that have been debased to a fetich. The whole question of ore-reserves has become a state of mind; there is a palsy on judgment, an eclipse of experience

The mining engineer, who once used his brains with cheerful confidence to formulate clear opinions regarding the condition of a mine, now stands panic-stricken on the edge of a difficulty from which he cannot retreat. From emphasizing the care required in determining the commercial value of ore, from the demand that the old happy-go-lucky style of inspection shall no longer be tolerated, from these and other efforts to ally science with experience, we have passed to that stage where engineers state tonnages with fearsome minuteness and quibble over assays of academic difference, until the last stroke of all is the suggestion, in South Africa, to "audit ore-reserves" and appoint a government-certificated-ore-reserve-auditor! In truth, it is time to pull up. West Australian mining has been suffering from this intoxication of theory until it is recognized that each estimate of the ore blocked out in a mine must be more conservative than the last. A variation which is no real difference becomes a discrepancy; a capable engineer's work is stultified by that of another equally capable, simply because the two of them do not sing a perfect duet of appraisal, and share-

holders tremble every time a cablegram comes from the mine manager It has gone so far that the general condition of a mine, the metallurgical treatment of the ore, the excellence of management, are of no avail when weighed against the estimate of the ore in reserve, indeed, one could maintain the shares of a mining company at a big premium without producing an ounce of gold or paying a penny of dividend, if only at stated intervals some engineer would certify that the ore-reserves had increased. In South Africa the sampler looms almost bigger than the consulting engineer, and in America the English-owned mines which are suffering from the same miasma are described by their engineers in terms which are so cautious that, whether twice as much or half the amount of ore stated should be extracted, no censure would be possible. In the old days they guessed twice and divided by two for accuracy's sake, nowadays the engineer, more solicitous for his own reputation than his client's welfare, hedges with providence and divides by two, so as to be safe Mining is being made ridiculous, there is an idea that risk can be eliminated, that shareholders can insist on supernatural closeness of calculation, that engineers must save their skins and that everyone must "get out from under" when an orebody happens to misbehave.

And in all this, have we not lost the main point of mining—what the old Cornish captains would call the "sport" of it—the exercise of experienced judgment in sizing up the present character and future prospects of a mine? It appears so. We no longer buy a mine for the chance of favorable development, the making of a mine out of a prospect, or a bonanza out of a struggling hole-in-the-ground; we take no risks; we buy *ore*,—as if by all the measuring and assaying and arithmetic we can eliminate the essential risk of estimating what we do not see, save at its edges. Sample and survey and calculate all you please, and then, even if you face the facts like a man and do not play tricks to avoid responsibility, you still have only one-half—sometimes not even one-half—of the essential problem. The future prospects of a mine remain beyond the vision of a timid *doctrinaire*; to gauge them fairly needs the ability to observe beyond the point of the pick, and the honesty to weigh facts, to an extent far beyond the shifting compromise of a conservative ore-reserver. It is time to get back to bedrock.

DREDGING AT OROVILLE *

By L. J. Hohl

(May 11, 1905)

The average running time of the boats varies a great deal in different months and under different circumstances. A new boat will be able to make better running time, as no serious breaks are likely to occur if it has been made strong enough in the first place. A breakdown of any magnitude, such as upper tumbler shaft, lower tumbler shaft or bucket line, will cut down the average running time. Where the boats are influenced by the stage of the water in the river, high water may seriously hamper them at certain seasons, and last winter was an exceptionally severe one in this respect, high water occurring as early as November, 1903, and being with us all through February and March of 1904. To show an extreme case I have taken a selected year in the run of a boat exposed to the high water, so that the year contains all the high water of last season.

Beside high water troubles, the bucket line was in bad shape and broke frequently, the upper tumbler shaft broke twice during the period under consideration, the lower tumbler and its shaft had to be renewed, also the conveyor-belt, and, to cap the climax, the power was abnormally unsteady and unreliable during most of that year. The running time of the boat, figuring on the basis of 365 days in the year and 24 hours to the day, was 16 hours out of 24. It may seem odd to call particular attention to the fact that in this calculation the year is taken as having 365 days and each day to have 24 hours, but when you look over the records of some of the boats you will find that some of the stoppages (such as high water, holidays, etc.) are not counted on, the owner or manager arguing that the dredge should not be charged with any delays not

* Abstract from paper read before the Thirteenth Annual Convention of the California Miners' Association, December, 1904.

originating in the dredge or its appurtenances. The simple truth that the dredge is not earning anything when it is stopped, whether such stoppage originates within or without the dredge, and which fact finds expression on the balance sheet of the company at the end of the year, is sufficient to show the fallacy of the assumption. Returning to the case under consideration, I append a tabulated statement:

Causes of Stoppages, in Per Cents

Belting	1.3
Bucket line	23.1
Lines breaking and changing	4.8
Cleaning up	1.7
Conveyor	5.3
Elevating machinery	1.5
Frictions and winches	2.5
General repairs	1.7
High water	15.6
Holidays	1.8
Ladder and ladder hoist	1.3
Lower tumbler	8.3
Oiling	3.8
Power off	4.5
Shaking screen	4.5
Stones, roots, and stumps	0.7
Upper tumbler	16.2
Water pump	1.4
Total	100.0

Another set of figures follows, covering the operations of dredges over a period of three years, and it is but fair to state that the high percentage shown under the head of power troubles is not attributable to the present company operating in the field, but to an older electric-power plant:

Causes of Stoppages, in Per Cents

Moving ahead	5.7
Power troubles	15.6
Repairs and holidays	75.4
Sand pump	3.3
Total	100.0

The average running time for the period given was 16 hours, 56 minutes. From other records extending over long periods of time it is probable that the best average running time of the boats will hardly exceed 18 hours out of 24, taking all causes of stop-

pages into consideration and figuring on 365 days per year. It is true that in a few cases better running time has been obtained, but where this has been the fact, it was due to conditions surrounding that case, which it is not safe to figure on in every instance.

While the figures so far presented were for Bucyrus boats, I have condensed from Mr Monroe's paper in the *Mining and Scientific Press* of February 6, 1904, corresponding data for a 5-cu. ft. Risdon boat, which I give below:

Causes of Stoppages, in Per Cents

Bucket line and ladder	30 7
Clean ups	7 7
General repairs	17 9
Lines	9 9
Power troubles	7 9
Pumps .	5 4
Screens	4 5
Stacker	9 4
Total	100 0

The data above extended over a period of one year, but not a picked one, it being a regular calendar year The bucket line on the boat was renewed during the year, which raises the percentage of time lost on account of the bucket line and ladder. Comparing the percentage of time lost on account of shaking screens and stacker with the percentage given for the picked year of the Bucyrus boat, we find, curiously enough, that the loss due to the shaking device in either case was exactly the same, while the Risdon stacker shows 9 4% as against 5 3% for the belt-conveyor. The running time of the Risdon dredge for the year amounts to 16 hours, 39 minutes out of 24 hours. The cost of repairs to the conveyor during the year for the Risdon boat amounted to $1,241.28, an amount which about equals the cost of the belt-conveyor in this particular instance, if the difference in lost time is taken into consideration.

As to the capacity of the different types and styles of boats, no fixed rule can be laid down, for the reason that the same dredge in different ground may not be able to make as much of a yardage, owing to local conditions. To mention one of these conditions, I would say that the washing of very sandy soil is more difficult than that of pure gravel, and it may be necessary to cut down the digging, for the reason that with full buckets the riffles become crowded.

A fair average yardage would be about as follows:

	Bucket capacity	Yd per month
Risdon dredge	3 cu ft.	25,000 to 35,000
Risdon dredge	5 "	35,000 " 45,000
Bucyrus dredge	3 "	35,000 " 45,000
Bucyrus dredge	5 "	50,000 " 65,000

The above figures would represent the work of a dredge, as now in use in the Oroville district, extending over a long period of time. The maximum obtainable will far exceed the figures quoted, and may be kept up for a short period with any one of the boats.

The cost of production depends to a great extent on the magnitude of the enterprise, which reduces the general expenses by dividing them up among a number of different boats, and by the chance of diminishing the cost of repair by the erection of shops near by. It has to be kept in mind that the operating expenses are influenced by local conditions, such as nature of the ground, general efficiency of digging and washing appliances, adjustment of motors and resistances to their work, extraordinary repairs occurring in short periods of time and a number of other details.

The following statement will give a fair representation of the extremes of the cost per cubic yard of material:

Operating Expenses Per Cubic Yard of Material

Power	1 06	1.20	1 15	1 61	1.77
Repairs	2.86	3 03	3.46	2 97	3 80
Labor	1 64	1 82	1 85	2 33	2.05
General expenses	0 64	0 67	1 23	1.28	0.73
Totals	6 20	6.72	7.69	8 19	8 35

The data for the above statement were obtained from different operators in the district; the period over which they extend is in each case not less than one year. In some of the figures given the taxes are included under the heading of general expenses, in others they are not. The cost of superintendence in some instances is included under the item of dredge labor, in others it is charged to

general expense, but in all cases the totals give all the expenses incident to the working of the dredge and keeping it in good running order.

The life of a boat has not been determined as yet, but with a well and strongly constructed hull, which is taken good care of, it should be not less than 12 to 15 years in this climate. It is self-evident that during that period a great portion of the machinery and appliances will have to be renewed over and over again, such as tumblers, ladder rollers, buckets, shaking screens, pulleys and shafts, spuds, conveyors, etc.; but the item of dredge repairs, as shown in the above statements of cost of operating, will cover these items, and there is no doubt that the experience gained so far, and which will be gained in the future, will have a tendency to gradually diminish such expenses, and, what is even more important, forestall the occurrence of larger mishaps.

THE COST OF MINING

(May 11, 1905)

The Editor

SIR—Mr. Ingalls' very pertinent article, "Cost of Mining in America," brings up a subject meriting the broadest discussion. There are few of us who have managed mining properties who cannot add something to the general fund of knowledge in this department. My own custom has been always to keep a monthly record, and at the end of the year to make a full general report in the form of a statement of cost and production. I happen to have retained a copy of one of these reports made several years ago, and no harm can be done now by making it public.

The results may not be "standard," but when it is taken into account that we were 60 miles from even a wagon road, and that the lode was only from 2½ to 3 1-3 ft. wide, and the orebodies small and scattered over three-fourths of a mile on the strike, it will be seen that worse might have been done Of course, in a report of this nature, only the general headings are required, and these sift down to:

Cost per ton:

- Prospecting and dead work.
- Ore extraction.
- Ore reduction.
- General expenses and sundries.

To determine these a more or less detailed series of accounts must be kept. In my own work, I have considered only a few general subdivisions as necessary, although strict account is kept of everything in detail. For instance: In my "statement of costs," etc., ore extraction is what is usually classed as "mining," and this I consider as made up, for the purpose of this report, about as follows:

Mining:

- Assay department:
  - Labor.
  - Materials
  - Sundries.

Ore breaking:
Labor }
Materials }
Including same for timbering, etc.
Sundries.
Administration:
Salaries.
General expenses
Office expenses

Under the head of "materials" is bunched everything used in that line during each month "Sundries" embraces minor expenses not coming under any one of the general headings adopted —item 11 of Mr. Ingalls' list. "General expenses" embraces the fixed expenditures in carrying on the work, such as items 4, 5, 9 and 10 of Mr. Ingalls' list.

In this way one gets a full and accurate idea of the work carried on during a year, without the need of tabulating all expenses in minute detail; for subdivision can be carried out to the point of stultifying the object in view. Although some improvements can undoubtedly be suggested, still I believe that such a compilation as I here present about covers the ground, and gives a much more full information than could fifty pages of written report.

All repairing, of whatever nature, in the mine, all drifting, sinking, raising and timbering of such works, running out waste, etc., I always class as "prospecting and dead work," and only consider the ore as mined when it is delivered to the bins or on the dump. All sorting and preliminary work necessary to secure workable ore should be charged to "ore extraction." In the case we now have under consideration, it will be noted that about 33 per cent of the cost per ton was due to prospecting and dead work. This was due to the urgent need, at all times, for ore; there being practically no reserves, and no regular, continuous orebody. Under the head of "general expenses," I always include improvements of all kinds, and have always charged these to the working expenses of the month in which they were made.

I venture to say that there are few cases where the costs in one mining district can be taken for granted as fitting some other camp; and where grave mistakes are sometimes made is in assuming this, when, as a fact, materials of all kinds may cost from two to three times as much in a new region as in some favored region

which the engineer making the "finding" may have in mind. In figuring on probable costs the greatest care should always be used, and the fact borne in mind that mining and milling costs that can be closely approximated do not constitute the sole expense of exploiting a new orebody; but prospecting, dead work and general expenses have to be taken into account, for they often amount to as much as do mining and milling. Especially is this the case with small, irregular lodes and orebodies of irregular shape

I hope that this letter may, at least, cause some one to take issue with me, thus enlarging the discussion on such a vital subject; or if not worthy of such attention, that it will bring out the latent knowledge of some well-informed co-workers who, because it all seems so simple to them, refrain from giving valuable experience to the profession at large

E. A. H. TAYS.

Fuerte, Sinaloa, Mexico, February 16, 1905.

SUMMARY[1]

Total production for year	$280,797 37
Total expenses for year	186,243.14
Difference	$94,554 23
What concentrate would produce net by shipping	711.95
	$95,266 18
Less gold purchased during year	1,172.19
Net profit for year, assay production	$94,093.19
Net profit for year, actual returns from bank	$93,757.65

[1] See table, pp 326–7

STATEMENT OF MINE PRODUCT, RELATIVE COST PER TON, MILL RESULTS, ETC.

January 1st—July 31st

	Captions.	January	February	March	April	May.	June	July
1	Tons of ore crushed (20 stamps)	1,630	1,592	1,610	1,671	1,860	1,481[1]	1,805
2.	Battery time, 24-hour days	27d. 3h	25d 16h	27d 9h	27d 9h	28d 1h	26d 11h	28d 19h
3	Average battery assay, oz Au	1 03	1 09	1 19	0 86	0 67	0 77	0 68
4	" " " " Ag	0 77	0 91	1 08	0 80	0 66	0 71	0 65
5	Total contents in ore treated, oz Au	1,678 90	1,735 28	1,915 90	1,437 06	1,246 20	1,140 37	1,227 40
6	" " " " " " Ag	1,255 10	1,448 72	1,738 80	1,336 80	1,227 60	1,051 51	1,173 25
7.	Total gold value, as per assays, in $	$35,393 17	$36,736 99	$40,644 93	$32,166 75	$26,494 51	$24,199 54	$26,173 50
8	Average tailing assay, oz Au	0 26	0 27	0 32	0 24	0 23	0 23	0 21
9	" " " " Ag	0 41	0 45	0 59	0 49	0 48	0 50	0 43
10	Tailing, total Au value, as per assays, in $	$9,160 92	$9,314 79	$11,219 12	$8,772 75	$9,374 40	$7,479 05	$8,176 65
11	Per cent apparent extraction Au	74 7%	75 2%	73 1%	72 1%	65 6%	70 1%	69 1%
12	" " " Ag	46 7%	50 5%	45 4%	38.7%	27 3%	29 8%	33 8%
13	Concentrate produced—tons							9 5
14.	" av. assay per ton Au							2 45
15.	" " " Ag							7 12
16	" total oz. Au, as per assay							23 27
17.	" " " Ag, " " "							67 64
18.	" " gold val., per assays, in $							$515 00
19	Total oz. Au, in bullion, as per assays	1,389 64	1,736 70	1,410 08	1,359 16	1,318 87	882 52	819 63
20	" " Ag. " " " " "	449 98	669 52	515 98	486 02	503 01	323 01	340 76
21	Bullion produced, value of gold, in $	$28,725 84	$35,900 24	$29,148 30	$28,096 29	$27 265 72	$18 243 86	$16 943 68
22	" " " " silver, in $	$247 49	$368 24	$283 79	$267 31	$281 68	$177 66	$190 83
23	" " total value, in $	$28,973 33	$36 268 48	$29,432 09	$28,363 60	$27,547 40	$18,421 52	$17 134 51
24	Product from sale of bullion, in $	$28,951 49	$36,238 27	$29,380 69	$28,347 24	$27,501 03	$18,400 89	$17,106 22
25	Cost per ton—Prosp. and dead work.	$2 94	$2 77	$4 02	$3 72	$2 42	$3 12	$2 84
26	" " " Ore extraction	$2 16	$2 26	$3 40	$2 70	$1 95	$2 97	$2 20
27.	" " " reduction	$1 60	$1 48	$1 40	$1 42	$1 15	$1 45	$1 30
28	" " " General expenses and sundries	$2 95	$2 32	$3 28	$3 00	$2 78	$2 11	$2 21
29	Total cost per ton.	$9 65	$8 83	$12 10	$10 84	$8 30	$9 65	$8 55
30	" monthly expenses	$15,714 31	$14,079 87	$19,781 28	$17,814 16	$15,382 54	$14,424 43	$15,507 27

[1] Short run, owing to short water supply.

N B—Figures in U S gold

STATEMENT OF MINE PRODUCT, RELATIVE COST PER TON, MILL RESULTS, ETC.—*Continued*

August 1st—December 31st

	Captions	August.	September	October	November	December	Totals and averages
1	Tons of ore crushed (20 stamps)	1,946	1,889	1,812	1,769	1,751	20,816 tons
2	Battery time, 24-hour days	28d 20h	27d. 19h	28d 11h.	28d 3h	27d 18h	311 days, 19 hours
3	Average battery assay, oz Au	0 68	0 68	0 53	0 53	0 40	0 76 oz average
4	" " " " Ag	0 68	0 71	0 57	0 54	0 41	0 71 oz average
5	Total contents in ore treated, oz Au	1,323 28	1,284 52	960 36	937 57	700 40	15,587 24 total
6	" " " " " " Ag	1,323 28	1,341 19	1,032 84	955 26	717 91	14,602 26 total
7	Total gold value, as per assays, in $	$28,158 62	$27,239 38	$20,548 08	$19,865 87	$14,708 40	$332,329 74 total
8	Average tailing assay, oz Au	0 22	0 20	0 19	0 17	0 16	0 22 oz average
9	" " " " Ag	0 50	0 44	0 41	0 35	0 28	0 44 oz average
10	Tailing, total Au value, as per assays, in $	$9,301 88	$8,387 16	$7,682 88	$6,863 73	$5,900 87	$101,634 19 total.
11	Per cent apparent extraction Au	67 6%	70 6%	64 1%	67 9%	60 0%	71 1%
12	" " " Ag	26 4%	38 0%	28 1%	35 2%	31 7%	39 4%
13	Concentrate produced—tons	8 0	9 0	10 00	9 0	8 0	53 50 tons [1]
14	" av assay per ton Au	3 94	3 76	3 77	1 94	1 60	2 92 oz average
15	" " " " Ag	9 22	6 70	6 82	3 86	3 96	6 44 oz average
16	" total oz. Au, as per assays	31 52	33 84	37 70	17 46	12 80	156 59 oz total
17	" " " Ag, " " "	73 76	60 30	68 20	34 74	31.68	336 32 oz total
18	" " gold val, per assays, in $	$688 00	$721 80	$803 40	$378 27	$280 48	$3,386 95 total
19	Total oz Au, in bullion, as per assays	1,140 59	361 15	399 83	247 60	144 00	4,877 26 oz total
20	" " Ag " " " " "	436.40	33 84	37 70	17 46	12 80	156 59 oz total
21	Bullion produced, value of gold, in $	$23,575 92	$21,707 89	$24 208 73	$14,865 62	$9,352 80	$278,034 89 total
22	" " " " silver, in $	$257 54	$213 08	$239 90	$148 56	$86 40	$2,762 48 total
23	" " total value, in $	$23,833 46	$21,920 97	$24,448 63	$15,014 18	$9,439 20	$280,797 37 total
24	Product from sale of bullion, in $	$23,792 55	$21,891 84	$24,418 57	$14,997 34	$9,434 90	$280,461 03 total
25	Cost per ton—Prosp and dead work	$2 50	$2 90	$3 14	$2 77	$2 68	$2 98 average
26	" " " Ore extraction	$1 86	$1 88	$2 27	$2 13	$2 56	$2 36 average
27	" " " " reduction	$1 16	$1 21	$1 32	$1 35	$1 31	$1 35 average
28	" " " General expenses and sundries	$2 00	$1 14	$1 74	$1 93	$2 48	$2 33 average
29	Total cost per ton	$7 52	$7 13	$8 47	$8 18	$9 03	$9 02 average
30	" monthly expenses	$14,681 57	$13,375 73	$15,224 43	$14,890 56	$15,366 99	$186,243 14 total

[1] In addition to these there are some 17½ tons of concentrate on hand produced during preceding year, valued at $1,340 U S gold

SOME PUMPING DATA

BY R. GILMAN BROWN

(May 18, 1905)

THE following figures have been collected from records kept at the Brunswick mine, Grass Valley, Cal., during the fall and winter of 1903–4. In the previous year an extraordinary flow of water was cut on the 1,250-ft. level (1,017 ft. vertical depth), which quickly drowned the Cornish pumps by which the mine had been previously drained The water raised to the 700-ft level (505 ft, vertically, below the collar of the shaft and 376 ft. below the drainage adit), and was there held by the 12-in. plunger of the Cornish system.

The problem of unwatering presented some complications, chief among which was the small size of the shaft compartments, which, in the upper and older part, were 32 by 39 in. clear. This precluded the use of large sinking-pumps and finally led to the selection of the air-lift for the actual unwatering, lack of efficiency being of but small moment when compared with the advantages offered in compactness, simplicity and small first cost. The use of the air-lift for the work was first suggested by E. A. Rix, of San Francisco

The general scheme for freeing the mine of water and installing a permanent system was worked out as follows· Starting from the rate at which the flooding water had risen in the shaft, it was determined that the permanent system should have a maximum capacity of 500 gal. per min.; a pump of that capacity was to be installed at the 700-ft level and the water lowered from that horizon with an air-lift to the 900-ft. level. There an auxiliary pump was to be placed, and the water again lowered by the air-lift to the 1,000-ft. level. Here a second permanent pump was to be placed, discharging to the 700-ft level. Below the 1,000-ft. level the unwatering was to be continued as far as possible, a pump station to

be cut out and the auxiliary pump to be removed to it, the remaining distance to be freed by the air-lift again, assisted by a small sinking-pump and by bailing

The event showed that the capability of the air-lift had been underestimated, for the water was lowered with it from the 700- to the 1,000-ft. level, and there held for five weeks while the second pump was being installed. During this period of installation the lift was handling 25 6 cu. ft. per min. to a vertical height of 288 ft, with a submersion below the surface of the water of 152.

Air-Lift—The air was supplied by a pair of duplex single-stage compressors, driven by electricity, and giving a united displacement of 9 91 cu. ft free air per revolution The speed was constant at 110 rev. per min. These compressors were placed 50 ft. from the collar of the shaft, and delivered the air through a receiver and a 4-in. air-column to the mine. The column for the air-lift was of 7-in. tubing, with flange unions, and it was lowered down the shaft on skids sliding on the track of the skipway The interior air-pipe was 2 inches.

The following table gives the record for a part of the unwatering period, arranged in a decreasing series, according to the ratio of submersion to lift. By "submersion" is meant the vertical depth of the bottom of the air-pipe below the surface of the water, and by "lift" the vertical height of the discharge above the surface of the water. "Free air" is assumed to equal the displacement of the compressor cylinders.

The data given in the table on page 330 seem conflicting, but they indicate clearly the change in efficiency of air-lift work due to increasing submersion. The power consumed was determined by meter readings over extended periods, and includes all the mechanical losses in the compressors and pipes.

Subsequently a 4-in. column and 1-in. air-pipe were used below the 1,000-ft. level, with the results given at the foot of the table. This was more in the nature of an experiment than anything else, and showed clearly the unsatisfactory operation under such an extreme condition.

As the final result of the experience gained in this work, it can be conceded that constant volume of compressor delivery (that is, constant speed of motors), and frequent changing submersion and lift are not conducive to economical work; exact adjustment of air volume and pressure to submersion and lift are essentials for good

efficiency, and under the conditions usual in work of this kind are not obtainable For regular air-lift work, as from deep wells, 32 to 35% is spoken of as quite within the range of possibilities. Notwithstanding the low efficiency, however, the method proved itself highly useful, and cost less in power and plant combined than any other that could have been applied.

Submersion per foot of lift Feet	Vertical lift Feet	Submersion Feet	Air pressure Pounds	Cubic feet per minute		Cubic feet air per cubic foot water	Efficiency per cent of power used, in water thrown.
				Free air	Water		
1 86	103	191	90	541	58 9	9.2	10 1
1 84	97	179	90	541	58 9	9.2	9.1
1 67	156	260	87	907	46.5	19 5	9 6
1 64	113	185	89	541	56 5	9 6	10 7
1 25	138	172	84	541	49.	11.	12 4
87	174	151	90	1090	48.5	22 5	7.9
86	204	175	90	1090	33	33.1	6 3
75	186	139	89	1090	43.	25.4	7.1
.72	189	136	89	1090	40.5	26.9	7.
65	240	157	94	1090	31.9	34.2	6 7
65	288	190	93	1090	25 9	42 1	6.2
59	273	161	99	1090	29 5	37.	7.2
.59	277	163	99	1090	30	36 3	6.8
58	264	152	98	1090	30 4	35.9	6 7
57	280	160	97	1090	27 7	39 4	6.7
.57	281	159	97	1090	27 7	39.4	6.4
53	287	153	96	1090	27.	40.4	6.4
[1].25	196	48	60	1090	9	121.1	1.8

[1] Below 1,000-ft. level

Electric Pump.—The electric pumps adopted for this installation were of the Aldrich type, manufactured by the Allentown Rolling Mills. The two main pumps were 5-plunger, single-acting, 6-in. diam. by 12-in. stroke, with a rated displacement of 66.7 cu. ft. per min. One of these was placed at the 700-ft. level, before the unwatering was commenced. It was driven by two 40-h. p., 440-volt, induction motors, through a single set of reduction gears. The other pump was a duplicate, except that it was driven by one 50-h. p. motor. The respective heads for these pumps are 376 and 290 ft. The auxiliary pump was of 3-plunger upright type, driven by a 40-h p motor. The current was brought into the mine by lead-covered, armored, three-conductor cables. As originally installed, the cable, as far as the 700-ft. level, was of a carrying

capacity of No 1 wire B. & S., and below that level of No. 3 B & S. It was found, however, that the lack of radiation caused a dangerous rise in the temperature of the upper cable, and it was accordingly reinforced by the addition of another one of No. 2.0 carrying capacity

Under full load these pumps have given a power efficiency of 72.3%, based on a 100% displacement of the plungers. The actual displacement of the plungers has been shown by tests to be 94.5% of the theoretical, so that the actual horsepower in water handled is 69% of the power delivered to the conductors at the collar of the shaft. This includes, besides the conductor loss, two series of lamps in the pump stations.

Cornish Pumps.—The Cornish-pump system presents the following: Stroke, 6 ft.; maximum strokes per min, $8\frac{3}{4}$; 1 plunger, 14-in. diam, under 128 ft head, 400-ft. level, 1 plunger, 12-in. diam., under 250 ft. head, 700-ft. level; 1 plunger, 12-in. diam, under 287 ft. head, 1,000-ft. level; 1 plunger, 12-in. diam., under 230 ft. head, 1,250-ft. level

The pump is driven by water, under 288 ft. kinetic head, the first speed reduction being by belt and the second by gear. The rod is of Oregon fir, 12 in. sq., and is supported by rollers in the customary fashion. There is an angle-bob at the 400-ft. level, where the shaft changes dip, and an ordinary counterbalanced operating bob on the surface, besides a balance bob at the 900-ft. level.

The data following are for the month of February, 1904: Horsepower in motive water, 181; horsepower in water thrown (on basis of full displacement), 65; apparent efficiency, on same basis, 53.7%. The actual water thrown amounted to but 75% of the displacement, because of the necessity of drawing back water from the columns into the pumps for considerable periods, in order to keep the pumps "solid." This is automatically done by floats and "siphons," and no special measurements were made to determine the actual displacement efficiency. This, however, with such slow-moving parts, should certainly be above 95%, with valves and packing in good condition, giving 51% total efficiency for the pump. There is, however, a further loss due to the stretch of the rods and to lost motion. In this case, at the 1,250-ft. level, this has been determined to be $3\frac{1}{4}$ in, or $4\frac{1}{2}$ per cent.

A most serious drawback to the use of the Cornish systems of pumps lies in the point touched upon in the last paragraph: The

fact that all the plungers must operate at the same speed, and with practically the same length of stroke, makes imperative the drawing back of some water to make up deficiencies at some of the pumps. The plunger, however, so long as it is raising to the next lift, is doing its work against the full pressure the whole time, even though nine-tenths of its water is being drawn back. This is inherent in the system, and can no more be avoided—though it may be minimized—than the change in the rate at which water "makes" in the various levels can be prevented

It would be interesting were data at hand for similar work by other styles and systems of pumps, but it seems highly improbable that efficiencies as high as 69% can be obtained by other than those electrically driven, with the possible exception of pumps using reheated air.

THE COST OF MINING

(May 25, 1905)

The Editor:

SIR—I am a reader of your valuable JOURNAL, and derive pleasure and profit thereby. Among the many things of interest it contains, to me there are none more so than the reports of the cost of mining; but in those reports we are never told what the cost is of those articles that make up the per ton cost; hence, as comparative figures, they are not very reliable. There is a great difference in the price of mining supplies if bought in large or small quantities. So also do the hours and wages paid differ in different localities, as do all other conditions affecting the character of operations. In giving those reports to the public, the character and hardness of the rock should be given, as well as cost of material; in fact, all things that add to the final expenditure. The mine owner reads the report perhaps as keenly as does the mine superintendent, and if it happens that he has had similar work done on his property at a greater cost, he will wonder why his man could not do it as cheaply as the other fellow, and thus many a good man may get "knocked."

This report is not intended as an example of how cheap this kind of work can be done (it cost $13.50 less per foot than the previous 200 ft.), but is more in the nature of a memorandum for the young mine superintendent who may not have had the experience in shaft-sinking.

Our supplies were shipped from Butte, 30 miles by rail, thence 8 miles by wagon over a rough mountain road, grade 200 ft. to the mile. When we started work on the shaft, it was already down 650 ft. The work involved in getting ready to sink, such as placing the station pump in a proper place, putting in a bulkhead, and cleaning out the mud—8 ft. of it—from the bottom of the shaft, cost over $200, which was charged up to the cost per foot of sinking. The size of the shaft where we started is 9 ft. by 4 ft. 6 in., the new work is 9 ft. by 4 ft. 10 in., all timber 10 by 10-in. fir.

Supplies for Sinking Shaft 214 Feet

4 kegs 40d nails	@	$3 63½	$14 52	
21 round-point shovels	"	0 84	17 64	
236 ⅝ by 8-in. lag screws	"	5.50	12 98	
20 lb. ⅝-in. cut washers	"		1 50	
4 plumb bobs	"		2 00	
200 feet plumb line	"		0 25	
6 mine torches	"	0.75	4 50	
Wicking for torches	"		0.15	
300 lb 1-in. round soft steel for hanging bolts	"	3 40	10 20	
48 1-in. square nuts, 44 lb	"	0 07½	3.30	
48 1-in cast washers, 32 lb	"	0 05	1 60	
9 axe handles	"	0 35	3 15	
2 axes	"	0 85	1 70	
2 doz. pick handles	"	0.27	6.48	
1 doz. 36-in. sledge handles	"	0 21	1 52	
100 lb axle grease—for cartridges.	"	0 06	6 00	
415 lb. of 2-lb T rails—for surface track	"	2 75	11.42	
50 lb. track spikes	"	0.04	2 00	
2,345 lb. blacksmith's coal	"	16 50	19 38	$120.29
18½ boxes candles—2040 Snowflake	"	3 00	$55.50	$55.50
2,600 lb. powder—Repauno gelatine	"	14.25	370.50	
10,700 ft. triple tape fuse	"	0.46	49.42	
2,400 caps—Lion brand	"	0.75	18 00	437.92
50,000 ft. timber and plank	"	17.50		$875.00

The ratio of plank and square timber used was, square timber 55.36%, 2-in. plank, 44.64%.

Labor

Blacksmith, 57 days	@	$4.00	$228.00	
Blacksmith helper, 24¼ days	"	3 00	72 75	300.75
Carpenter, 77 days	"	4.50		$346.50
Superintendent				556.92
Contractors				3,424 00
Pumping and hoisting account				1,916.05
Plant maintenance and additions account				534.79
				$8,567.72

Hardware supplies	$0.561916	per	foot
Candles	0.259345	"	"
Ammunition	2.046355	"	"
Timber—except guides	4.0887	"	"
Pumping and hoisting account	8.9535	"	"
Plant maintenance and additional account	2.4986	"	"
Blacksmith work	1.405374	"	"
Carpenter work	1.61916	"	"
Superintendent	2.60	"	"
Contract price	16.00	"	"
	$40 03	"	"

For hoisting the rock we used a bucket with the bail pivoted below the center, and for lack of height under the sheave it was hung just 2 ft. under the cage; to dump it we hinged a door on the opposite side of the shaft from that on which we caged the cars; on this door we placed the car and dumped the rock into it from the bucket. We used the cage to lower and hoist men, also to hoist rock from the 400-ft. level, where we had two shifts, of two men each, running a drift. While the mine made considerable water, the shaft was quite free from it; what there was came from near the surface and amounted to 50 gal. per hour, which we hoisted to the 600-ft. station and dumped it into a launder, which carried it to the mine sump. We started to sink November 29, and finished February 19. The shaft being well in the foot-wall the granite was very hard for 160 ft.; the remainder, while it was good stiff ground, broke well. The contract price was $16 per foot, the company furnishing all material; there were four contractors, who employed eight others, thus making four men per shift. We used two D-32 Ingersoll-Sergeant rock-drills. When sending up rock, one of the shaft men acted as top carman, for which I allowed the contractors $3.50 per shift; this man also handled the rock from the drift, so that when there was no rock coming out of the shaft we had no top man to pay. We found this plan advantageous both to the company and contractors, for the man that worked on top got $4, the same as the men on the bottom, hence he got a "move on him." The distance sunk—214 ft.@$16—cost $3,424; to which add $357 for top carman; dividing by 864, the number of shifts, gives $4.37 per shift per man. The top work was charged to pumping and hoisting account.

James Humes.

Basin, Mon., May 15, 1905.

THE COST OF MINING

(Editorial, June 8, 1905)

THE contributions to this discussion have not been numerous, but they have come from men entitled to speak with authority. On the main points there has been practical unanimity, for instance, the need of a simple but comprehensive system of accounts and the subordination of the cost of mining to the vital question of profit per ton of ore. Among the factors which explain the marked differences of cost made apparent by the reports of mining companies, two are specially notable; we refer to the effect of sorting and the efficiency of labor. In districts where mining operations follow small and irregular seams of rich ore scattered through a large mass of material of low grade, it is a fundamental problem whether to work the rich ore separately, obtaining a clean high-grade product, or to break down the entire mass of mineralized lode, with subsequent sorting at surface. It is a question whether the maximum profit can be secured by breaking the rich streak by itself (that is, to "resue") or to minimize the cost of breaking by taking the full width in one blasting operation. In the one case the expense incurred underground is greater; in the other, sorting supervenes at surface. The choice of methods will depend largely upon the contents and character of the extra width of rock broken down with the main ore-streak. Here is where the "cost of mining" trembles in the balance. Each case must be worked out individually, according to particular conditions; and, in the weighing of the factors affecting the final profit, there comes the test of good management.

The quality of the labor employed is another basic factor. It is hardly realized, by shareholders and directors, how great a difference in the cost of mining is created by inefficient labor. In this respect the mines which are able to use the contract system and those which are free from the unintelligent tyranny of the miners' unions have a great advantage over those that are domi-

nated by walking delegates and are compelled to employ unskillful workmen at "day's pay" Thus the Joplin and the Flat River districts in Missouri afford a strong contrast Among other aspects of the labor problem, it is, we think, a safe generalization, that mine operators find it economical to make the best of whatever native labor may be available. In Korea, in Mexico, in Burma, in most countries where the natives can be trained to do the work in mines, it is cheaper to educate them to the American or European methods than it is to introduce the high-priced workmen of more advanced communities, because the extra skill secured thereby is rarely compensation for the climatic effects on foreigners and the dependence upon men who cannot be replaced save with great loss of time and the incurring of a one-sided obligation. In all comparisons initiated between working costs obtained under labor conditions so diverse as those of the United States, South Africa, Mexico, and Western Australia, it is necessary to have regard to this factor.

In a recent issue Mr. Philip Argall made some pertinent remarks concerning the ability to discover ore in a mine as being at least as precious as that of keeping down the costs of operation after the ore has been found. He quoted an instance the identity of which it was not difficult to recognize. Undoubtedly, skill in seeking orebodies is one of the most difficult to appraise, because it must be, to a large extent, dependent upon accident; nevertheless, it is well for those in control of mines—especially such as maintain an expensive organization—to realize that no quality is so directly contributory to profitable mining as the instinct or experience that enables a superintendent to follow the ore or, when it fails, to pick up a new trail of ore deposition. That is why "tributers" or lessees make an expensive mine management look silly when they take over a mine supposed to be exhausted and forthwith uncover valuable ore-shoots Occasionally, the increase in output, coincident with the tributer's régime, is traceable to patches of rich ore hidden by miners previously on "day's pay"; but, as a rule, it is simply the result of the initiative displayed by men who are no longer working for a company, but for themselves. Any method of management which utilizes this characteristic of humanity is likely to induce economy in the cost of operation.

DEEP MINING

(Editorial, June 1, 1905)

THE finding of gold at 4,161 feet in a Bendigo mine is affording subject for comment, in Australia particularly. Murchison's dictum regarding the non-persistence of gold-quartz veins is resurrected, and that worthy geologist, but unfortunate generalizer on mining matters, is held up to ridicule. When Murchison wrote, 50 years ago, gold mining afforded no data for large statements regarding persistence; and even to-day the discussion of the subject is academic unless it is tied to the economic aspect; in other words, veins may or may not persist to depths beyond man's reach; the point is, that man will make no effort to follow them if they do not pay. It is the problem of the persistence, not of gold-quartz, but of pay ore. Thus, our esteemed contemporary, the *Australian Mining Standard*, says that "the question (of depth in mining) is, of course, largely governed by the cost of working." It is *wholly* governed by it; mining is not a scientific pursuit, but a money-making business, based, of course, on the application of scientific knowledge. That is why eminent geologists occasionally go astray.

It is interesting to know that quartz carrying native gold, probably in coarse particles visible to the eye, has been intersected by man's burrowing at a depth of three-quarters of a mile; but this does not imply profitable mining at that depth. The ore in the New Chum Railway mine, at Bendigo, was cut by a winze sunk 305 ft. below a crosscut at 3,856 ft.; the discovery is the result of expensive exploration. The last profitable mining was at 3,350 ft. We question whether the orebody will prove remunerative, simply because we are aware that mining at Bendigo, on the whole, has not been profitable below 2,500 ft. or even at a shallower horizon, despite occasional patchy discoveries and a few orebodies of such dimensions as to pay spasmodic dividends which, while they have lasted, obliterated the memory of a much longer series of calls. Even in South Africa the romance of an indefinitely deep search

for the "banket," through shafts planned to go from one to two miles deep, has paled of late It is recognized that the profitable character of the "reefs" decreases in depth. As we said two years ago, even Methuselah died. It is as well to get alongside of fact; the more money is wasted on academic theories, the less is available for sound mining. Meanwhile, observant men no longer repeat the fallacy of enrichment in depth, or even of indefinite persistence of pay ore; but, recognizing conditions as disclosed in world-wide mining, they are extending the horizon of profitable operations by reducing costs In 1850 a lode would have been considered "played out" if the yield decreased from 5 oz. of gold at surface to 2 oz at 200 ft., because it would then have ceased to be profitable. Twenty years ago people were glad to begin with a yield of an ounce; and, if the ore reached to 1,000 ft. before it fell to half an ounce, they were well satisfied. Nowadays we can go deeper; and, though the diminution continues, we can snatch profits from material yielding less than a quarter of an ounce, thereby extending the economic horizon another 1,000 ft This is merely an illustration, but something of the sort really does occur in practical work; and it suffices to emphasize the conclusion, that if you want to know about the structural peculiarities and distribution of ore in a lode, you do well to ask the geologist; if you want to know whether a mine will pay, and how long, you had better ask the man who has managed mines.

NOTES ON MINE REPORTS

By Chester F. Lee

(June 8, 1905)

General Principles.—A report should be clear, definite and complete. Want of clearness in statement is a fatal defect. Muddy statements, confusion of ideas and running one subject into another are worse faults in this class of writing than any other. Clear expression results from clear thought. Everything should be figured out and thought out beforehand, all doubts settled, and then a statement made in as few and simple words as may be All that is to be said on any one head should be said at one place; part of a subject in one place and part in another leads to confusion. Definiteness is equally essential Hazy and ambiguous statements as to essential points are inadmissible. They are signs of incompetence or a desire to mislead. A man who knows his business and is honest will make statements in a form that cannot be misunderstood.

Many reports otherwise good are fatally defective for want of some detail essential to the complete understanding of the proposition. Judgment is here necessary to distinguish between the trivial and unessential and that which is vital and apposite. Nothing can be omitted which is a link in the chain of facts that leads to the conclusions stated, or is essential to their clear comprehension; but nothing should be included that is not essential to this end. That mining is the business of making money out of ore should never be lost sight of The object of a report is primarily commercial; it is a matter of business. Such technical matter as is necessary to clearness and completeness has place, but nothing further. The temper in which the matter should be approached is judicial. No personal bias or feeling should enter. All should be cold, hard facts, and the conclusions such as can be justly drawn from the facts stated. Everything should be ascertained with exactness,

nothing guessed at or left to chance, and no stone left unturned to check conclusions in all possible ways Pains taken in this last particular will save many a costly blunder

Divisions —Requirements will vary greatly, but the following heads (or their equivalents) will cover most cases, and often many of them can be dispensed with. The order of treatment is not insisted on:

1. Conclusions.
2. Situation (Geography)
3. Claims (Surface extent).
4. Title
5. History
6. Ore-bearing Zone.
7. Character of Deposit.
8. Geology
9. Mineralogy
10. Developments (Workings).
11. Production
12. Ore Developed.
13. Ore Values.
14. Treatment (Process and Handling).
15. Costs and Proceeds.
16. Plant
17. Working Methods
18. Assays and Sampling.
19. Maps
20. Miscellaneous
21. Appendix.
22. Index

Conclusions.—It is the conviction of the writer that the conclusions should be the first thing in a report. The busy man wants to know nothing more, and all readers get at the meat of the matter sooner from knowing the net results at the outset. An engineer of prominence requires all reports submitted to him to have the conclusions reduced to the following terms:

Ore zone ft. long by ... ft. wide by . . ft. deep. Ore-shoots in the above (enumerating each) . . ft. long by ft. wide by . . ft. deep Ore can be mined for $. per ton. Ore can be treated for $ per ton. By . process Per cent of extraction ... ... Requires assay value to pay of . .. Assay value found . ....

It is not possible to fit all cases to so rigid a form, but it illustrates the requirements of those who want things boiled down to the last degree. They require reports to be clear, crisp, net. Conclusions should be put in as few and clear words as possible; too much pains cannot be taken in making them at once a summary and epitome of the whole. The conclusions, though standing first, are of course written last.

Situation.—Under this caption come such matters as geographical location, accessibility, transportation facilities, topography and climate.

Claims.—Claims or surface extent of property should be fully set forth and a complete map prepared, showing every possible detail of surface boundaries and divisions, survey lines, contours, surface improvements, buildings, etc. A good set of photographs is an aid to clearness.

Title.—Title to the property under examination is properly matter for a lawyer's opinion, but if it is merely possessory, or rests on patents or its equivalent, so state.

History.—The salient points in the history of the property should be next given. Points of failure are often more interesting than those of success. To know what to avoid is half-way to know what to do. Properties of any age are sure to have gone through several stages and many vicissitudes, of interest to the prospective purchaser.

Ore Zone.—By "ore-bearing zone" is meant the extent of ground in which ore may reasonably be looked for. A succinct statement of the proportion of the property likely to yield a profit is desirable. Evidence on this head is looked for, not only in the ground in question, but in near-by property and throughout the district, if need be.

Character of Deposit.—Without a fair working knowledge of ore deposits in general and an intimate acquaintance with the deposit under discussion in particular, nothing worthy can be set down. An outline only can be given of what suitable treatment of this section requires. It would include the origin and form of the deposit, the physical and geological character of the walls or limiting change of formation or structure; the strike and dip of the deposit; the occurrence and frequency of shoots, chimneys or other enriched areas, their origin, form, dip, pitch, etc. In general, it may be said that every characteristic, peculiarity and salient feature of the orebody should be described. Occasional sketches are an aid to clearness.

Geology.—The essential points of the local geology should be carefully examined and succinctly stated; not a scientific treatise, but a plain statement of whatever affects the economic aspects of the case is the thing. Dikes, faults, slips, cross-courses, change of formation and similar phenomena should be described, and their

influence on the size, continuity, mineralization, etc., of the orebody considered. Suitable maps and sketches are helpful in showing these details.

Mineralogy.—This will comprise an enumeration of the minerals in the ore, and in the gangue and walls; a discussion of the chemical and physical changes these minerals have undergone, oxidations, alteration products, etc Values in the various minerals to be determined, and a differentiation made between what is profitable and what is not.

Developments.—A detail account of all the workings of the mine, with the results that have been accomplished. Here again a good set of maps is indispensable. Generally a vertical longitudinal section of the deposit will show most of the openings, but often frequent cross-sections are necessary. A map of the whole mine in plan is the basis for this work.

Production.—This is best presented in tabulated form; dates, character of ore, parts of the mine producing it, values in the several metals, total gross values, deductions, costs and the like, in as full detail as is possible. A concise history of the output makes the text of this heading.

Ore Developed.—"Ore developed" covers what used to be designated "ore in sight." The quantity of ore ready for extraction and exposed on four sides should be listed under "developed ore"; what is exposed on two or three sides is "probable ore," and everything else comes under a consideration of the "future of the mine," or some similar phrase. As much of this should be tabulated as possible.

Ore Values.—The values found in the orebodies from the systematic sampling of the mine should come next, in tables, with such comment as is indispensable to lucidity.

Treatment.—The handling of the ore from the time it is broken in the mine (and even the method of breaking) until the finished product is marketed should be given in detail. When more than one form of handling or treatment is possible they should be compared, and their relative efficiency, cost, saving, etc., given. The percentage saved, and the losses and their causes in the various steps of the process, should be given in full.

Costs.—Costs are divided into *mining, metallurgical* and *general.* Each should be given in detail, with analysis of all elements that produce them, under divisions of labor, supplies, etc. With

costs, naturally comes a consideration of proceeds. Metallurgical processes, with their losses and proceeds, are set down in one column and the values of the metals treated, wasted and saved in another. It is here that the net value of the ore comes out. This is the main point of the report, and appears as such in the initial paragraph giving the conclusions.

Plant.—A description of the plant and other surface improvements comes next, with such alterations and additions thereto as may be advised. Questions as to adequacy of plant already installed, and of relation of plant to output and ore-reserves, are here discussed.

Working Methods.—An outline plan of opening up the property if not already developed, and a discussion of working methods underground, is indispensable

Assay and Sampling.—The table of assay results and the calculations of averages should be relegated to an appendix if there is any number of them. Method of sampling should be clearly set forth in detail, so that a judgment can be formed of the thoroughness of the work and of the justness of the conclusions reached.

Maps.—The essential maps are: Surface plan; the workings in plan; a vertical longitudinal section of the orebody. To these may be added a key-map of the region where the property is situated, a geological section of the immediate vicinity, plans of levels separately, cross-sections of orebodies at typical points, plans of surface improvements, plans of stopes at different stages, details of timbering, etc., assay plans, and an almost infinite variety of other special and detailed drawings.

Miscellaneous.—All the collateral information useful in connection with the property not strictly belonging elsewhere can be collected here.

Appendix.—After the body of the report all additional data should be placed, as: Detailed lists of assays and calculations of average value, tests made in connection with treatment investigations, smelter or mill returns in detail, lists of surface improvements, buildings, etc., inventories of machinery, outfit, supplies and the like. Statements and matters that are purely financial should be in an entirely separate document.

Index.—Any report of more than four pages without an index or table of contents is faulty to that extent.

MINE REPORTS

(Editorial, June 15, 1905)

THE "Notes on Mine Reports," which appeared in our last issue, may awaken expression of diverse opinions. Mr. Chester F. Lee has many sensible things to say; one of these we venture to emphasize. It is true that "a man who is honest will make statements in a form that cannot be misunderstood" The spirit of science does demand straight thinking and the direct expression of ideas; the application of science to mining asks for the same rectitude of mind. Equivocation, ambiguity and indirection of any sort in a mine report are unscientific even when unintentional; but when deliberately adopted, they are unprofessional. We have no patience with a report written in such manner that, whether the mine either does half as well or yields twice as much as the engineer vaguely predicts, it can yet be interpreted as a vindication of correct judgment. Such work is mere hocus-pocus, which evades responsibility and plays the fool with the client or company paying for the report; it is dishonest, in that it is a failure to "deliver the goods" —in this case, an opinion that cannot be misunderstood. We have seen the development of this tendency among engineers more careful of their reputation than of their duty. It is a bad practice; the engineer who receives $5,000 for his examination and report is paid ten times as much as the man whose fee is $500, for the simple reason that he has a well-earned reputation which he puts to risk every time he truthfully expresses his judgment or gives his appraisal of a mine. The physical exertion, the mental exercise, the time consumed are much the same in both cases; in fact, the junior—or the man with the lesser reputation—is apt to expend more muscle, nerve tissue and time than he of the big fees; the valid reason for paying the one ten times more than the other is that the former has already won a reputation which he imperils each time his judgment is put to the test. If he plays round the subject, gives conclusions in magniloquent but ambiguous phrases,

shifts his responsibility to subordinates, or in any way refuses to fulfill his bargain—the opinion which faces the facts and accepts the responsibility for an experienced judgment—he is dishonest. The statement quoted from Mr. Lee is prefaced with the clause "a man who knows his business"; and this proviso (interpreted in a sense Mr. Lee does not intend) anticipates the reply of those who adopt the methods just criticised; they will say that they know their business well enough to "get out from under" when any responsibility overhangs them; they deem it clever to get large fees for the *simulacra* of opinions, and they consider it worldly-wise to "take care of their reputations" by avoiding statements for which they can be brought to book. But such conduct is foreign to the right spirit of the engineering profession; it is not even sound business; it is the attitude of a tricky tradesman.

THE INTERVAL BETWEEN LEVELS

(Editorial, June 22, 1905)

THE proper distance between levels is a practical point that is often presented to the judgment of mine managers. Those who avoid the fatigue of thinking, plan their main drifts 100 ft. apart, because a century is a neat number and it represents an interval which is honored by usage, if by nothing else. However, there are others who are not the slaves to empiricism of this unintelligent kind. In South Africa, it has been found that economy, without loss of efficiency, is gained by increasing the distance between levels. Before the war, 150 ft. was the interval generally adopted; since then, this has been doubled in certain instances, such as the Roodepoort United mine, and there is now talk of attaining a maximum of 600 ft., measured on the dip of the lode. A saving in mining cost of from one to three shillings per ton is anticipated.

The distance necessary between working levels depends, in the first instance, upon the character of a lode. On the Rand, the beds of "banket" are fairly regular in their behavior and in their gold content; therefore, frequent drifts are not needed for exploratory purposes; the ground between any two levels, that are 300 ft. apart, can be assumed to possess average characteristics to an extent impossible in most of the variable veins which represent the ore deposits of other regions. Levels 60 ft. apart are common in mines based upon thin veins of rich gold-bearing quartz, subject to eccentricity of dip and the sudden changes due to short ore-shoots. The ratio, between the cost of driving a drift in rich ore and the value of the output to be obtained from the stopes overhead, constitutes a problem quite different from that of large levels in a low-grade mine. Although, before the eventual exhaustion of a mine, it may be necessary to drive intermediate drifts, it is obvious that, for exploratory purposes in a fairly uniform lode of low grade, it is not necessary to make these longitudinal cuts near together. The money spent in extending such levels remains unproductive until stoping begins; and, in big mines, not only is capital thus expended unprofitably, but the maintenance of drifts not in use represents

a constant charge which it is advisable to avoid. At the Calumet & Hecla, levels were placed 100 ft. apart, as measured on the dip of the lode, or about 65 ft. in vertical interval In this case the drift did not even fulfil an exploratory purpose, because it included only a fraction of the total width of ore. The Tamarack benefited by the error of its big neighbor, and the levels were run every 180 ft., measured vertically, giving 300 ft. along the lode. Afterward, sub-levels were extended at intervals of 100 ft At the Burra Burra mine, of the Tennessee Copper Company, the main levels are 300 ft. apart, but the lode is crosscut at each 100 ft. of sinking; and, when actual extraction begins, sub-levels are extended from the crosscuts. These initial crosscuts and the less frequent main levels are adequate for exploratory purposes; for stoping, the sub-levels are needed in order to afford points of attack and to facilitate transport. In a mine the output of which goes to a smelter, it is undesirable to drop the ore down chutes of excessive height, because a powdery product hinders the working of the furnace. When the ore is destined for a stamp-mill, the disintegration is not injurious; on the contrary, it performs part of the work of the crushing machinery.

Drainage is another factor. In wet ground, it is expedient to run the new level at such an interval below the working drift that the block last opened up will become drained while the upper one is being stoped. Excessive water hinders mining and adds to all the costs of operation; by adjusting the lifts between levels, the pumping can be limited and the drainage of the lode can be regulated. In mines where the loose ground of a fault either coincides with, or crosses, the lode, it will be found that the water-level follows the main shaft as sinking progresses. Faults also affect the problem in hand because, when a lode is subject to such dislocations, it becomes necessary to drift at short vertical intervals in order to determine the position of the vein or of the ore-shoot. A lift of several hundred feet is impracticable under such conditions, because a displacement of the lode might change the whole plan of development and render such a level inoperative. In mines of this kind (and most metal lodes are liable to such eccentricities of behavior) the function of a drift is exploratory first, and operative afterward; it serves the purpose of testing the vein and of finding the ore-shoot before it is turned into an underground artery for the transport of material to the shaft.

THE COST OF MINING—II

By W. R. Ingalls

(July 15, 1905)

In my first paper on this subject, which has been commented upon by Messrs. Finlay, Argall, Tays and Brown, I did not look forward to a discussion of the advisability of keeping accounts which would show the cost of mining, nor did I contemplate a discussion of the itemization of mining costs, except incidentally. My purpose was rather to draw out the experience, reduced to dollars and cents, in mining under various conditions, and by itemization and classification of costs to analyze the differences in conditions. Mr. Finlay appreciated this intention, and remarked that, even in cases of wide difference of conditions, there would still be found operations in which the conditions were more or less parallel. It was far from my purpose to uphold the desirability of attaining a low cost of mining per ton, at expense of the maximum profit; indeed, such argument as I presented on that topic was quite the reverse; but I aimed to draw out the reasons why mining costs should vary so much, not only under obviously dissimilar conditions, but also under conditions that appear approximately analogous, or at least that may so appear to those who have not minutely studied them.

In considering the cost of mining from this viewpoint, I have taken the trouble to compile the following data, which are mostly from official reports, either the originals or the abstracts published in The Engineering and Mining Journal. They refer only to gold, silver, copper, lead and zinc mines; coal and iron mines are excluded from the scope of this inquiry; and the case of the Lake Superior copper mines is reserved for a separate article. Few, if any, engineers being familiar with the fundamental conditions which determine the cost of mining in all of the districts mentioned, explanations from those who are acquainted with them will surely be welcomed, as will be also such further data as will throw more light on the subject.

Grass Valley, California.—North Star Mines Company in 1902 mined 17,399 tons of ore, at cost of \$15.90 per ton, divided as follows. Operating expenses, \$7.76; general expense, \$1.11; extraordinary expense, \$0 57; development, \$5.04; improvements, \$1.42.

Calaveras County, California—Utica Mine. Large vein on Mother Lode. In producing about 300 tons of ore per day there are required two 10-hour shifts, each consisting of 12 miners, 12 helpers, 16 shovelers and 6 trammers; total, 45; in addition to which a crew of 10 timbermen is employed. Miners are paid \$3; timbermen, \$3; helpers, shovelers and carmen, \$2.50 per day.[1]

Sutter Creek, California.—Central Eureka Mining Company, in 1902, produced 43,545 tons of ore, at cost of \$1,795 for mining, and \$0.519 for developing.[2]

Randsburg, California.—Yellow Aster Mining & Milling Company. Eugene H. Barton[3] reported the cost of mining 14,601 tons of ore as follows:

MINING	Cost	Per ton
Labor	\$10,696.69	\$0 73260
Timbering.	803.55	0 05500
Timber	2,661 47	0 18228
Powder	580 68	0 03977
Fuse	93 90	0 00643
Caps	44.97	0 00308
Lights	306 62	0.02100
Blacksmithing	498.32	0.03414
Development	628 72	0 04306
Haulage	643 90	0.04410
Hoisting	697.92	0 04780
Total	\$17,656.40	\$1 16620

GENERAL EXPENSES	Cost	Per ton.
Miscellaneous	\$1,460 10	\$0 10000
Assaying	160 61	0 01100
Salaries	950 87	0 06507
Tailing	313 33	0 02146
Incidentals	440 92	0 03020
Total	\$3,325.83	\$0 22773

J. H Collier, Jr., *Transactions* American Institute Mining Engineers, 1899.

[2] *Idem*, June 6, 1903, p. 869.

[3] THE ENGINEERING AND MINING JOURNAL, January 28, 1904.

The general expense is to some extent chargeable to the milling. Water is obtained from wells 6 5 miles from the mine, whence it is pumped at a cost of 19c. per 1,000 gal., which comes to 22.05c. per ton of ore, no part of this being included in the cost of mining. The mine is equipped to produce 500 tons of ore per day. Fuel-oil costs 4 5c. per gal.; lumber, $32.50 per M. The rate of wages is as follows: Miners, 9 hours, $3; muckers, 9 hours, $2.50; car-men, 9 hours, $3; timbermen, 9 hours, $3.50; amalgamators, 12 hours, $4; stationary engineers, 12 hours, $4; hoisting engineers, 8 hours, $3.50; pump-men, 12 hours, $3.50.

Black Hills, South Dakota.—Homestake mines. Vein of mineralized schist, 300 to 500 ft. wide. Worked partially open-cast, partially underground. In 1898 mining cost, $2.17; general expense, $0.14. In the year ended June 1, 1903, the cost of mining 1,279,075 tons of ore was $2.04, not including general expense; total cost, exclusive of milling, was $2.37. Mine opened to depth of 1,100 ft.

Bingham, Utah.—Massive deposits of pyrite (gold, silver and copper-bearing) in limestone, dipping moderately. Operated chiefly through adits Timbering with square sets.

Utah Consolidated Mining Company; Highland Boy mine, operated through six adits to 700-ft. level, and by shaft to 800 ft. Ore transported by aerial tramway 12,700 ft. to Bingham station, thence by rail to smelter at Murray. In 1902 produced 167,713 tons of ore at a cost of $1.45 for mining and tramway, $0.25 for exploration and development; in 1903, produced 190,256 tons, at a cost of $1.78 for mining and tramway, $0.033 for exploration and development; general expenses not included.

Mercur, Utah.—Deposits of gold ore in limestone, lying approximately flat. Mercur Mining & Milling Company, in the year ending June 30, 1902, extracted ore at cost of $1.41 per ton, including general expense; in year ending June 30, 1903, extracted 346,359 tons, at cost of $1.30 per ton. Mining done by caving system. Mine operated through adit, with electric haulage, two locomotives, 10-h.p. each, capable of hauling 20 tons at six miles per hour.

Frisco, Utah.—Horn Silver Mining Company in 1900 produced 27,411 tons of ore, at cost of $4.88 per ton, of which labor on ore was $2.087; on dead work, $0.703; on surface, $0.850; supplies, timber, fuel, etc., $1.24.

Cripple Creek, Colorado.—Gold mining in veins in igneous

rocks (chiefly andesite). Mines operated through shafts; depths moderate; water variable. Miners receive $3.40 per day of eight hours (42.5c. per hour). Coal costs about $4.60 per ton. Considerable timbering required. Mining costs generally from $2.50 to $3.50 per ton of ore hoisted, including taxes, insurance and general expense. Sorting of the ore on the surface materially increases the cost per ton of ore shipped.[1]

Stratton's Independence, Ltd., in year ending June 30, 1902, mined 230,699 tons of ore, at cost of $4.18 per ton, of which $1.27 per ton was on account of development vork. The latter comprised 264 ft. of shaft, 1,521 ft. of raises, 160 ft. of winzes, and 11,738 ft. of drifts and cross-cuts. Total depth of main shaft, 1,430 ft. In year ending June 30, 1903, 229,797 tons were hoisted, at total expense of $3.70 per ton, of which $0.87 was for development, which comprised 1,716 ft. of raises and 8,387 ft. of drifts and cross-cuts.

Leadville, Colorado.—Blanket vein, containing massive shoots of argentiferous galena, blende and pyrites. Operated through shafts; depths moderate. Rather larger quantity of water to pump. Timbering with square sets. Miners receive $3 per day. Mining costs large producers about $2 per ton, including general expense.

Ouray, Colorado.—Camp Bird vein, a fissure dipping about 70°; average width, 6 to 7 ft. Vein material, quartz, impregnated with gold, galena, pyrite and chalcopyrite. Ore occurs in shoots, wherein the grade is subject to considerable variation. Mine opened by adit 2,200 ft. long. Timbering is required only in the raises, winzes, chutes and floors of stopes. About 40% of the ore broken in stoping is taken out, the remainder is left in the stopes; the percentage of waste trammed out is small. Mine worked by two 8-hour shifts; 3.25-in. machine drills mostly in favor; 40% dynamite; compressors driven by electric power. Large-machine men receive $4.50 per shift; helpers, $4; small-machine men, $4; smiths, $4; helpers, $3.25; timber-men, $4 to $4.50; helpers, $3; shovelers, $3; trammers, $3; enginemen, $4.50.[2]

During the year ending April 30, 1903, there were broken 111,245 tons of ore, wet weight, of which 71,793 tons were delivered to the mill and 39,452 tons were left in the stopes. The ore milled, less moisture, amounted to 66,825 tons. The cost of mining, not

[1] J. R. Finlay, THE ENGINEERING AND MINING JOURNAL, November 21, 1903.
[2] C. W. Purington, *Transactions* American Institute Mining Engineers, 1902.

including general expense, was $367,838, or $5.50 per ton on the ore delivered to the mill (dry weight), or $3.50 per ton on the ore broken (wet weight).

Telluride, Colorado.—Liberty Bell mine, 1902, produced about 7,500 tons of ore per month, at cost of $2 to $2.30, not including general expense.

Butte, Montana.—Immense veins, dipping steeply, in granite. Ore, chalcocite, bornite and enargite, with pyrite, in a quartzose and granitic gangue. Veins attain a width of 100 ft. and more, 10 to 20 ft stopes being common. The cost of mining at Butte ranges from $3 to $4 per ton.

The following returns were made by the Butte copper companies to the assessors of Silver Bow county, Montana:[1] Colusa Parrot, 265,113 tons, mining cost, $3.70 per ton; Butte & Boston, 245,333 tons, $3 27; Parrot, 253,284 tons, $2.81, Boston and Montana, 907,227 tons, $2 61; Anaconda, 1,392,835 tons, $3.49; Washoe, 106,588 tons, $3 79; Montana Ore Purchasing Company, 293,332 tons, $3.54. These figures, submitted for taxation purposes, are of little technical value.

Anaconda Copper Mining Company: The production in 1897–1898 was 628,051 tons of ore from the Anaconda mine, and 813,487 from the Syndicate mine. The cost per ton was as follows:

Item.	Anaconda	Syndicate
Labor	$2 470	$2.244
Explosives	0 105	0.133
Coal	0 144	0 144
Supplies	0 110	0.108
Assaying	0 007	0 006
Administration and general expenses	0 177	0.138
Personal injuries	0 028	0 023
Timber	0 290	0.305
Water	0 018	0 014
Repairs and renewals	0.327	0.219
New constructions	0 237	0 110
Total	$3.913	$3 444

Cœur d'Alene, Idaho.—Steeply dipping fissure veins and shear zones, containing large and wide bodies of silver-lead ore. Mostly opened by adits; water power available and generally used; timber abundant and cheap. Miners receive $3.50 per day. Three meth-

[1] The Engineering and Mining Journal, July 25, 1904.

ods of mining employed: (1) timbering (square sets); (2) filling; (3) timbering and filling. Cost of mining and milling, $2 50 to $3.50 per ton (Finlay).

The Bunker Hill & Sullivan Mining Company in 1902 extracted 260,500 tons of ore, at cost of $2.09 per ton. Miners receive $3.50; muckers, $3; timbermen, $4 In 1903 the cost of mining 288,713 tons of ore was $1 633 per ton, not including general expense, which came to 11.5c per ton. All the ore was trammed from the mine by electric haulage through the Kellogg tunnel (12,000 ft long), at a cost of 7c. per ton. In addition to the ore, 47,000 tons of waste was trammed Drifts, cross-cuts, raises and winzes cost an average of $7 31 per foot, 4,043 ft. being driven.

Douglas Island, Alaska.—Auriferous dike of syenite in carbonaceous slate. Dike stands at steep angle and attains width of 420 ft. Situated close to the sea, with respect to which the position of the orebodies has great influence on the methods and costs of mining. Mines formerly worked chiefly open-cast; henceforth the underground mining will be the more important. Miners receive $2.50 per day, with board and lodging

Alaska-Treadwell, opened by shafts to 900 ft. below sea-level. Water less than 50 gal. per min ; levels opened 110 ft and 150 ft. apart; no timbering required; hoisting by skips from storage bins. Vertical pillars left to support walls, 20% loss of ore estimated In stoping, one drill breaks 34 96 tons of ore, with consumption of 12.53 lb. of No. 2 dynamite, in 10 hours, in addition to which 0.85 lb. of powder per ton of ore is consumed in bulldozing.

In the year ending May 30, 1903, the Alaska-Treadwell mined 759,625 tons at cost of 0.9022, not including general expense. Development work amounted to 6,145 ft. An average of 33 machine drills was employed in the mine (7 on development, 4 on cutting out, 7.5 in pits, and 14.5 in underground stoping). The total of holes drilled was 783,360 ft., and of ore broken 906,625 tons, making an average of 1.14 tons per foot of hole drilled. The average work per machine per 10 hours was 34.4 ft. of hole drilled. Machine drillers in the open pit were paid $3.50 per day, with board and lodging; underground, $2.50, with board and lodging; the difference being due to the extra-danger in the open-cuts.

Alaska-Mexican, 1900: Mined 166,449 tons, at cost of $1.0834 per ton, not including general expense. Development work, 3,094 ft. In 1901, mined 178,960 tons, at cost of $1.1923. Development

work, 5,441 ft In 1902, mined 207,455 tons, at cost of $1,059 Development work, 5,286 ft Scale of wages: Machine drillers, $2.50; helpers, $2 25, common labor (white), $2; smiths, $4, plus board and lodging in each case. Indian labor, $2, without board or lodging

Alaska United, 1901: Ready Bullion mine—171,642 tons raised, chiefly from 450- to 600-ft levels Cost per ton, $1 1788, not including general expense. Development work, 2,535 ft "700-ft." mine—89,840 tons raised, chiefly from 400-ft level. Cost, $1.2281 per ton. Development work, 1,708 feet

Ducktown, Tennessee.—Huge lenticular deposits of cupriferous pyrite in schist Lenses vary from a few feet to 150 ft. wide, with great length, dipping steeply. Opened as yet to only moderate depth. Ore stoped out in chambers; no timbering.

Tennessee Copper Company, 1902, mined 250,769 tons, at $0.8411, not including general expense

Flat River, Missouri.—Immense shoots of lead ore; galena disseminated in magnesian limestone; position approximately flat; stopes 80 ft. high and 60 ft. wide not uncommon. Mines operated through shafts, 300 to 500 ft. deep, with efficient equipment. No timbering required; water, 200 to 2,000 gal. per min. Miners receive $1.85; shovelers, $1.75; all nine hours. Coal (from southern Illinois) costs $2.20 per ton. Mining cost, about $1 per ton, including general expense and delivery to mill, on basis of about 1,000 tons per day, but not including development work, construction or amortization of plant. These statements refer to the conditions before the recent strikes, as result of which wages have been increased, time reduced to eight hours, and efficiency of labor decreased, somewhat increasing the cost of mining Prospecting in this district, both from surface and underground, is done chiefly by diamond drilling.

Rossland, British Columbia.—Zones of sheared rock, mineralized with auriferous pyrrhotite and chalcopyrite up to width of 100 ft. or more, dipping at about 70°. Vein-filling very hard; stopes timbered with square sets; ore stands 10 cu. ft. to the ton. About 20% is sorted out as low-grade (to second-class dump). Timbering costs about 21c. per ton of ore raised, 27c. per ton of ore shipped [1]

Center Star Mining Company, operating on large vein of

[1] B. McDonald, *Journal* Canadian Mining Institute, Vol. VI, p. 129.

auriferous copper ore. The costs per foot of development work and per ton of ore mined during the year ended September 30, 1903, were as indicated in the following table:

	Development			Mining, per ton.
	Winzes, per ft	Raises, per ft	Drifting, per ft	
Drilling	$6 10	$7 31	$4.53	$0 405
Blasting	2 48	2 40	1 08	0 030
Explosives	3 13	3 72	2 72	0 145
General mine labor	0 51	0 64	0 43	0 040
Mine lighting, candles	0 26	0 19	0 14	0 015
Mine lighting, electric	0 30	0 22	0 13	0 010
Smithing	1 00	1 14	0 72	0 065
Tramming and shoveling, direct	5 51	0 65	1 21	0 240
Tramming and shoveling, apportioned	0 64	0 35	0 42	0 085
Timbering, labor	1.81	3 08	0.02	0 190
Timbering, material	0.33	0 57	0 01	0 010
Machine drill fittings	0 86	0.94	0 60	0 055
General mine labor	1 57	1 18	0.84	0 090
Hoisting, underground	4.79			
Hoisting, main shaft	1.48	0 89	0 94	0 190
Compressed air	1.74	2.08	1 07	0 120
Mine ventilation	0 23	0.17	0 13	0 015
Pumping	0.71	1.09	0 34	0 035
Assaying	0.55	0.47	0.14	0 030
Surveying	0 20	0 17	0.11	0 010
General expense	3.57	2 71	1.51	0 185
Totals	$38 77	$29.97	$17 09	$2.065

The development work done, and the cost, and the averages per foot, are shown in the table below:

	Feet	Amount	Per ft
General work		$3,058	
Raises	168 0	5,577	$29.97
Winzes	79 0	3,062	38 77
Drifting	2,903 5	49,622	17 09
Totals	3,168.5	$61,319	$19 35

Under general work are included stations, re-timbering, machinery and equipment, repairs and maintenance.

The total quantity of ore mined and sold was 88,387 tons, of which 3,934 tons came from development work. The average cost of mining, viz, $2.065, is computed on the 84,453 tons of ore stoped. The development work, costing $61,319, amounted to about $0.725 per ton on the ore stoped.

Ymir Gold Mines, Ltd., in 1901, mined 70,640 tons of ore, at average cost per ton of $1.814 for mining, $0.150 for administration and $0.279 for general and contingent expense; the last two items should be proportioned between mining and milling.

Joplin, Missouri—Deposits of zinc-blende and galena in lenses of chert in limestone; also sheet deposits of similar ore. Considerable variation in character of ore as to hardness, and as to roof, but the sheet deposits are generally very hard. The deposits lie approximately flat and at moderate depth, say 150 to 250 ft. Life of the mines is short and conditions decree cheapness of plant rather than durability. Ground is not developed ahead, except by churn-drilling from surface. Cost of opening mine to produce 75 to 100 tons of ore in 10 hours, including concentrating mill, is about $15,000. Miners are paid $2.25 and shovelers $2 per day. About 25 to 37.5 tons of ore is stoped per drill per day. The cost of mining in ground that requires no timbering is approximately as follows: Miners and helpers, 17c.; trammers and shovelers, 8c.; drill sharpening, etc., 5c.; explosives, 10c., hoisting (labor), 6c.; supplies, 4c.; fuel, 9c.; supervision, 9c.; total, 68c.; not including any pumping or general expense. The actual costs in six different mines operated during the same year were as follows:

Surface plant.	$0.000	$0.000	$0.004	$0.010	$0.017	$0.006
Rep. surface plant	0.007	0.005	0.002	0.011	0.017	0.008
Underground plant	0.000	0.000	0.002	0.016	0.053	0.016
Rep. underground plant	0.000	0.005	0.001	0.021	0.040	0.014
Hoisting	0.023	0.032	0.023	0.035	0.042	0.031
Fuel.	0.028	0.031	0.036	0.040	0.067	0.040
Mining	0.248	0.258	0.241	0.231	0.282	0.252
Development.	0.000	0.041	0.022	0.011	0.023	0.019
Blacksmithing	0.029	0.033	0.041	0.034	0.035	0.034
Shoveling and tramming	0.121	0.174	0.123	0.148	0.161	0.143
Explosives	0.085	0.073	0.096	0.110	0.125	0.098
Tools	0.003	0.003	0.004	0.020	0.015	0.009
Timber and track	0.005	0.003	0.004	0.011	0.028	0.010
Lighting	0.004	0.007	0.006	0.008	0.010	0.007
Lubricating	0.000	0.000	0.000	0.000	0.001	0.000
Pumping	0.000	0.000	0.000	0.000	0.020	0.004
Accidents.	0.002	0.000	0.002	0.000	0.009	0.003
Totals	$0.56	$0.66	$0.60	$0.71	$0.94	$0.70

The sheet-ground of the Joplin district is a mineralized, fine-grained chert, averaging about 8 ft. in thickness, extremely hard and requiring the heaviest type of machine-drills.

THE COST OF MINING—III

BY W. R INGALLS

THIS article is simply to summarize the mining costs at Lake Superior, as reported by the companies which make detailed statements, none of the Lake mines having been included in my earlier articles

The mines at Lake Superior are opened on veins of amygdaloid and conglomerate, mineralized with 0 5 to 2 per cent of native copper In width, the veins range from 12 to 20 ft. They are of great longitudinal extent, and are also persistent in depth. They dip from 30° to 60° (which has an important bearing on the cost of mining) and are commonly operated by inclined shafts. Developments are generally extended a long way ahead of stoping. Equipments and methods are of the highest order. They have been described in Mr. Rickard's book, "The Copper Mines of Lake Superior."

Atlantic, 1901.—Ground broken in openings and stopes, 24,883 fathoms; in stopes only, 22,320 fathoms. Development work comprised 281 ft. of shafts, which cost $24.52 per foot (underground expense alone), 11 ft. of forks, at $13.78; 72 ft. of winzes at $10.63; and 6,223 ft. of drifts, 8 × 10 ft, at $4 84 Stoping cost $4.09 per cu. fathom (*i. e.,* 6 × 6 × 6 ft. = 216 cu. ft.). Quantity of ore milled, 409,124 tons. On this basis mining costs per ton were as in the table given herewith.

1902.—Ground broken in openings and stopes, 25,764 fathoms; in stopes only, 23,197 fathoms. Development work comprised 313 ft. of shafts, at $24.17; 27 ft. of forks, at $15.16; 75 ft. of winzes, at $9.89; and 5,982 ft. of drifts (8 × 10 ft.), at $4.96. Stoping cost $3.98 per fathom. Quantity of ore milled, 446,098 tons. On this basis mining costs were as in the table given herewith.

1903.—Ground broken in openings and stopes, 27,063 fathoms; in stopes only, 24,300 fathoms. Development work comprised 225

ft. of shafts, at $22.80; 6 ft. of forks, at $14.45; and 6,961 ft. of drifts, 8 × 10 ft, at $5.40 Stoping cost $4 17 per fathom. Quantity of rock milled, 431,397 tons On this basis, mining costs per ton were as in the table for 1901, 1902 and 1903, as given herewith:

	1901	1902	1903
Development work	$0 093	$0 086	$0 099
Stoping	0 223	0 208	0 235
Timber, tramming and labor	0 297	0 268	0 273
Timber, material and supplies	0 088	0 065	0 057
Pumping and operating air compressors			
Labor	0 029	0 227	0 032
Fuel	0 084	0 229	0 027
Supplies and material	0 014	0 011	0 010
Superintendence and surface labor	0 086	0 076	0 074
Supplies and materials used on surface	0 039	0 033	0 042
Fuel	0 132	0 075	0 044
Fire insurance and taxes	0 026	0 017	0 022
Expenses and sundry repairs	0 011	0 012	0 015
Electric lighting and wiring			0 007
Total[1]	$1 092	$0 907	$0 937

[1] These costs for the Atlantic are exclusive of construction account and New York office expense, but include breaking and sorting the ore The stoping for 1901 was 22,320 fathoms; for 1902 it was 23,197 fathoms, and for 1903 it was 24,300 fathoms

Baltic, 1901.—Rock hoisted, 144,603 tons; rock milled, 114,703 tons, or about 71 per cent of the rock hoisted. Development work comprised 492 ft. of shaft, at $22.75 per foot (underground expense only), and 2,733 ft. of drifts, at $5.80. Reckoning the mining cost upon the tonnage of rock hoisted, the items of expense were as in the table given herewith:

Development		$0 187
Mine captains		0 025
Timbermen and helpers		0 073
Miners and laborers		0 409
Trammers		0 292
Mechanics and civil engineers		0 030
Timber and supplies		0.187
Teaming		0.010
Power drills:		
Engineers and firemen	$0.014	
Mechanics	0.028	
Fuel	0 057	
Supplies	0 047	
		$0.146

Brought forward		$1,359
Hoisting		
Engineers and firemen	0 060	
Mechanics and laborers	0 016	
Fuel	0 083	
Supplies	0 027	
Fire insurance	0 005	
		$0 191
Selecting and breaking		0 144
General surface work		0 085
General expense		
Superintendence and office expense	0 047	
Taxes	0 104	
		$0 151
Total		$1 930

1903—Rock hoisted, 528,517 tons, of which 38,134 was poor rock from shafts and other openings; only 146 tons of poor rock was sorted out in the rock house, 490,237 tons being sent to the mill. Development work comprised 480 ft. of shafts, 5,561 ft of drifts, 328 ft of crosscuts, and 76 ft. of forks. The cost of mining reckoned on the basis of 490,237 tons of ore milled, including development work, was as follows:

Superintendence and labor, underground	$0 681
Hoisting	0 057
Power drills	0 068
Timber and supplies, underground	0 169
Superintendence and labor, surface	0 031
General expense and surface supplies	0 019
Rock-house expense	0 091
Total	$1 116

Franklin, 1900.—Old Franklin mine Hoisted, 118,460 tons; milled, 113,930. Cost of mining and hoisting, $1.16 per ton. Development work comprised 1,024 ft. of drifts, at $7.91; 162 ft. of crosscuts, at $7.87.

Franklin Junior mine. Hoisted, 170,896 tons; milled, 154,641 tons. Cost per ton of rock hoisted, $1.43. This cost is stated to be not excessive, considering the narrowness of the lode and large amount of water in the mine. Development work comprised 205 ft. of shafts; 37 ft. of winzes; 4,023 ft. of drifts, and 417 ft. of crosscuts. Average cost of drifting, $7.38.

1901.—Old Franklin mine. Hoisted 121,336 tons, at cost of $1.12 per ton. Development work comprised 138 ft. of drifts, at $8.77 per ft.; and 497 ft. of crosscuts, at $8.37.

Franklin Junior mine, Amygdaloid lode. Hoisted 123,350 tons

of rock, at cost of $1 26 per ton. Development work comprised 256 ft. of shaft, at $13 45; 2,598 ft. of drifts, at $7.37; and 192 ft. of crosscuts, at $6.89.

Franklin Junior mine, Peninsular lode, conglomerate. Lode from 12 to 18 ft. wide, averaging 15 ft Entire width mined Rock hoisted by 6-ton skip. Hoisted 81,726 tons, at cost of $1.19 per ton. Development work comprised 176 ft of shaft (8 × 20 ft.), at $11 30 per ft (raising); and 2,631 ft. of drifts, at $7 82.

1902.—Old Franklin mine. Hoisted 109,097 tons, at cost of $1.22 per ton. Development work comprised 285 ft. of drifts, at $8.63; and 359 ft. of crosscuts, at $7 48.

Franklin Junior mine, Peninsular lode, conglomerate Hoisted 209,484 tons of rock, at cost of $1.05 per ton. Development work comprised 147 ft of shaft, at $14 39; 5,322 ft. of drifts, at $7.71, and 44 ft of crosscuts, at $7 35.

Osceola, 1901.—Tons of rock mined, 958,272; hoisted, 892,172 tons; milled, 793,207 tons. Cost of mining per ton of rock hoisted, $1 334.

1902.—Tons of rock mined, 969,835; hoisted, 908,264 tons; milled, 836,400 tons. Cost of mining per ton of rock hoisted, $1.17.

Quincy, 1901—Tons of rock mined, 905,022; hoisted, 924,173 tons, milled, 886,266 tons Average total force employed, 1,602 men; miners, 533. Average wages of miners on contract, $62 per month.

1902.—Tons of rock mined, 983,730; hoisted, 984,594 tons; milled, 953,019 tons. Average total force employed, 1,636 men; miners, 562. Average wages of miners on contract, $62 per month

1903.—Tons of rock mined, 1,024,164; hoisted, 1,006,173 tons; milled, 958,935 tons. Average total force employed, 1,624; miners, 586. Average wages of miners on contract, $62 per month

Tamarack, 1901.—Tons of rock mined, 773,783; rock hoisted, 688,622 tons; rock milled, 626,905 tons. Cost of mining per ton of rock, $1.97; cost per ton of rock milled, $2.44.

1902.—Tons of rock mined, 837,568; rock hoisted, 763,209 tons; rock milled, 658,720 tons. Cost of mining per ton of rock, $1.81; cost per ton of rock milled, $2.30.

1903.—Tons of rock milled, 657,920. Cost of mining per ton, $2.32.

Wolverine, 1900–1901—Rock hoisted, 223,971 tons; rock

milled, 190,104 tons. Development work comprised 523 ft. of shaft, at $16 82 per ft.; and 6,861 ft. of drifts, at $7.10. Stoping 10,381 fathoms cost $9.22 per fathom. The cost of mining per ton on basis of rock hoisted was as given herewith:

Development work	$0 257
Stoping.	0 428
Timbering	0.015
Tramming	0 190
Mine captains and labor	0 077
Mechanics .	0 015
Hoisting and pumping	0 078
Compressor	0 099
Teaming, etc	0 004
Supplies and fuel.	0 038
General expense	0 120
Total [1].	$1 321

[1] A deduction of $0 216 should be made from the total on account of profit of supplies furnished contractors

1901–1902.—Rock hoisted, 213,650 tons; milled, 187,482 tons. Development work comprised 463 ft. of shafts, at $16.91; 66 ft. of raises, at $13.35; and 7,772 ft. of drifts, at $6.97. Stoping 11,350 fathoms cost $8.59 per fathom. On the basis of rock hoisted, the cost of mining per ton was as given herewith:

Development work	$0 295
Stoping	0 457
Timbering	0.020
Tramming	0 190
Mine captains and labor	0.095
Mechanics	0.024
Hoisting and pumping.	0 071
Compressor....	0 180
Teaming, etc..	0.005
Supplies and fuel...	0.065
General expense.	0.180
Total [2]	$1.582

[2] A deduction of $0 24 should be made from the total on account of profit on supplies furnished contractors

1902–1903.—Rock hoisted, 299,922 tons; rock milled, 279,001 tons. Development work comprised 431 ft. of shafts, at $16.98; 197 ft. of raises, at $10.50; 4,531 ft. of drifts, at $6.63. Stoping 17,121 fathoms cost $7.54 per fathom. On the basis of rock hoisted, the cost of mining per ton was as given herewith:

Development work	$0.131
Stoping	0 430
Timbering	0 019
Tramming	0 175
Mine captains and labor	0 069
Mechanics	0 019
Hoisting and pumping	0 067
Compressor	0 085
Teaming, etc	0 003
Supplies and fuel	0 052
General expense	0 147
Total[1]	$1 197

[1] A deduction of $0 175 should be made from the total on account of profit on supplies furnished contractors.

CYANIDING SULPHO-TELLURIDE ORES

By Philip Argall

(July 11, 1903)

The successful use of bromo-cyanide in the treatment of the unroasted sulpho-telluride ores of Western Australia has attracted quite a little attention in the United States, more particularly, perhaps, from those having mining interests in Cripple Creek, Colo The very fact that sulpho-telluride ores can be treated without roasting, appeals at once to the small producer, who immediately sees a method for reducing his ore to bullion without the use of the usual cumbersome and often expensive roasting plant.

The method of working the Western Australian ores in the raw state, by means of fine grinding and subsequent treatment with bromo-cyanide, is known as the "Diehl" process, apparently now established as an economic and commercial success in the treatment of Kalgoorlie ores. I herewith propose to compare this process of cyaniding with the roasting method as heretofore practiced on the ores of Cripple Creek.

The Kalgoorlie ores contain a large quantity of calcium and iron carbonates, together with a small quantity of magnesia. Estimating the latter component as $CaCO_3$, Mr. H. Knutsen gives the following approximate analysis of three samples· Insoluble, 57.98 per cent, 59.61 per cent, and 76.91 per cent; $FeCO_3$, 19.29 per cent, 13.94 per cent, and 12.11 per cent, and $CaCO_3$, 22 55 per cent, 26.73 per cent, and 9.18 per cent.

The sulphur appears to have been neglected in the analysis. Mr. Alfred James, however, gives as a typical analysis of these ores: SiO_2 about 50 per cent, Fe 10 per cent, Al_2O_3 5 to 20 per

* This article was published originally in "The Mineral Industry," Vol XI. In connection with this article reference should be made to the article by Mr Hoover on page 39 of this book.

cent or more, MgO 1 to 5 per cent, S 3 to 7 per cent, Cu 0.1 to 0 3 per cent, Pb trace, Zn 0.02 per cent As trace, Sb 0.02 per cent, Te 0 03 to 0.1 per cent, and $CaCO_3$ 6 to 17 per cent. Ores of this character after roasting when the solutions reach them form a lime-iron cement which sets hard in the tanks and greatly interferes with, and often prevents, the percolation of the solutions through the charges For this reason early attempts at leaching the roasted ores at Kalgoorlie were far from successful; furthermore, these Australian ores, while containing an appreciable quantity of free gold in a comparatively granular condition, still require to be ground very fine in order to obtain a high rate of extraction; the fine grinding produced troubles in the subsequent handling of the slime, and led to the early introduction of filter-presses, which soon became standard in the cyanide practice of Western Australia.

One of the most successful combination processes for reducing the sulpho-telluride ores of Kalgoorlie is briefly outlined as follows: Crushing dry to about 30-mesh size, roasting in mechanical furnaces, fine grinding and pan amalgamation in dilute cyanide solutions, separating the sands from the slimes, treating the latter in the filter-presses and the former in tanks, or, as an alternative, reducing the ore under treatment to such a fine state of division that it is all successfully treated in the filter-presses, thereby abolishing the leaching in the tanks. According to Mr. Alfred James, the Kalgoorlie sulphide ores yield, without roasting, from 50 to 70 per cent extraction when treated by agitation with ordinary cyanide solutions. My experiments on Cripple Creek telluride ore gave almost identical results; in fact, the lowest extraction on 30-mesh size raw ore that I have observed is 54 per cent. It is perhaps permissible to state that fuel is quite expensive in Kalgoorlie, and water may be said to command famine prices, from which it is evident that roasting is at a disadvantage, costing, it is said, on those low tenor sulphur ores, from $1 to $3 per ton, while power costs from 70c. to 90c. per horse-power per day. Under these conditions, a wet process for working the ore in the raw state has at least a fair show.

The use of the halogen cyanides as accelerators in the cyanide process was discovered and patented by Dr. Gaze in 1892, and in February, 1893, a cyanide mill near Reefton, N. Z., used chlorocyanide in the solutions; but owing to difficulties in precipita-

tion, the process was soon abandoned In 1894 Messrs. Sulman & Teed, of London, patented a bromo-cyanide process, and to these gentlemen is due the credit of applying bromo-cyanide to the direct treatment of telluride ore. It is well known that cyanogen in the semi-molecular or nascent state has a powerful action on gold, that bromo-cyanide itself has but little if any solvent power on gold, but when added to a cyanide solution, it not only liberates a molecule of cyanogen from the latter, but also contributes its own cyanogen, thus: $KCn + BrCn = KBr + 2Cn$

Bromo-cyanide must be considered as a cyanogen liberator, and it is no doubt through the intense chemical activity of the nascent cyanogen thus liberated that the tellurides are attacked, at least to the extent of setting free part of their contained gold. Briefly, the combination bromo-cyanide process evolved by Dr Diehl is as follows:

(1) Stamping the raw ore with or without amalgamation, as may be found expedient

(2) Separating the heavy minerals from the gangue by concentration.

(3) Roasting the concentrates and returning the roasted tellurides to the batteries for amalgamation, or selling the concentrates to the smelters.

(4) Sliming all the tailings from the concentrators so the material will pass a 200-mesh screen.

(5) Agitating this fine pulp for at least 24 hours in cyanide solutions, to which a solution of bromo-cyanogen is added from time to time.

(6) Filter-pressing the agitated slimes.

The Diehl process is fully described by Mr. H. Knutsen[1] in a very able and interesting paper from which the following comparative data of costs are taken. The process is in use at one property alongside a roasting plant, both treating the same class of ores; in the roasting plant two-thirds of the ore is treated in filter-presses and one-third in leaching tanks, while in the Diehl all the ore must be filter-pressed.

In the roasting process, 3,411 tons were treated, which yielded 5,287 oz. of bullion and no concentrates, while with the Diehl process 5,888 tons were treated, yielding 5,201 oz of bullion and

[1] *Proceedings of the Institution of Mining and Metallurgy*, 1902, London; see also "The Mineral Industry," Vols. IX and X.

leaving 3,819.47 oz in the concentrates. If the concentrates represent but 0.5 per cent of the ore, as reported, then practically 42 per cent of the value of the crude ore is locked up in about 30 tons of concentrates These latter are treated at the smelting works. A summary of expenditure per ton of ore treated during August, 1901, is given in the subjoined table

	Roasting Process			Diehl Process		
	s		d	s.		d
Superintendence	1	5	051	1	0	013
General stores and charges..	1	4	306	1	7	466
Electric light	1	4	561	1	2	514
Assay, retorting and smelting	1	9	036	1	6	075
Fuel .	9	2	548	3	5	746
Water	3	5	046	3	2	347
Compressed air	1	4	254	2	0	209
Filling and emptying vats	1	2	564			
Labor, general ..	1	1	978	1	10	618
Engine driving and firing	0	11	479	0	7	.662
General repairs.	3	3	058	2	3	224
Screens, shoes and dies. .				0	0	340
Elevating .				0	3	481
Cyanogen bromide				4	0	046
Potassium cyanide	3	0	277	2	9	596
Zinc .	3	2	418	2	2	227
Filling and emptying presses. .	1	8	253	2	6	171
Filter cloth	0	4	736	0	3	098
Chemicals . .	0	1	049	0	1	001
Firing roaster .	1	2	958			
Agitation . .	1	2	723			
Royalty . .				1	9	196
Totals	37	4	295	32	9	030

Taking the difference in fuel cost between the two processes, and adding the expense of firing the roaster, the approximate cost of roasting is found to be 6s. 11.7600d. The cost of bromocyanide is 4s per ton of ore treated; to this, the royalty for the use of the process should be added, and a total of 5s. 9 24d. is obtained as an offset to the roasting, which shows 1s. 2 5d. in favor of the Diehl process. It was claimed that the same quality of ore went to both plants, but the Diehl gave a return amounting to 3s. 8d. per ton more than that from the roasting process. This comparison appears to me to be somewhat favorable to the Diehl process, if, indeed, a strict comparison of the costs of the rival processes was intended; for example, the capacity of the

roasting plant appears to be about 60 per cent of that of the Diehl, yet the cost for supervision, engine driving, etc., is about 50 per cent greater for the smaller plant. It is in the final products of the plants, however, that the most unfair comparison creeps in, the roasting process produces all its yield in bullion, while the Diehl leaves about 42 per cent of the bullion content of the ore in the form of high-grade concentrates, which can neither be handled nor roasted without loss of metal. There is also an additional smelting charge for extracting the values from the concentrates that is apparently not included in the foregoing expense table. Furthermore the roasting plant is not credited with flue dust or sweeps, and one cannot believe that the roasting of ores of this character would be attempted without the usual equipment of dust flues and settling chambers.

In a newer Diehl plant the concentrates, amounting to about 5 per cent of the ore treated, are roasted and returned to the batteries for amalgamation, the pulp from the raw as well as from the roasted ores mingling together are treated in agitators for 24 hours with cyanide and bromo-cyanogen solutions. The final tailings are said to "average from 1 to 2 dwt. gold per ton, no matter whether the original ore contained 1 oz. or 4 oz. gold per ton." The consumption of chemicals is given at about 3lb. KCn and 1.25 lb. BrCn per ton of ore. The working cost is summarized as follows: Milling, 4s. 0.59d., concentration, 1s. 7.19d.; treatment, concentrates, 1s. 4.08d.; extraction, 17s. 1.02d.; total, 24s. 0.88d.

The bromo salts alone amount to 5s. per ton of ore treated. It will be noticed that bromo-cyanide is not depended on to break up the gold tellurides completely, hence these minerals are first concentrated out as far as possible, and afterward roasted to set the gold free for amalgamation. In the next place, a tailing approaching $2 in value can scarcely be considered a satisfactory termination of such an elaboration of processes. Yet it is extremely interesting to know that such good work can be accomplished by a wet process, or at least one that eliminates from 80 per cent to 95 per cent of the roasting usually found necessary in treating sulpho-telluride ores. Such a process will have a great future in places where roasting is expensive, either through lack of fuel, or the high sulphur content of the ore;

provided that in either case the bromo-cyanide will extract the values.

The sulpho-telluride ores of Cripple Creek are virtually altered granites, phonolites, and andesites, containing slightly more silica and considerably more iron and sulphur than the original rocks, but on the whole practically of the same chemical composition Tellurium and fluorite are little more than traces in the ores received at a custom works which contain but little carbonate, and when roasted, exhibit no tendency to harden or set in the tanks unless an excess of lime has been added Ordinarily a good extraction can be obtained on roasted ores crushed no finer than 30-mesh size (0 017-in opening). The sulphur content of the ores varies from 1 per cent to 7 per cent, and may be said to average approximately 3 per cent. These ores are quite easily roasted, and the entire process of roasting and cooling would vary in cost from 30c to 50c. per ton, depending on the sulphur content and on the arrangement of the roasting plant. About four years ago, I made a complete estimate of the cost of cyaniding Cripple Creek ores at a proposed new works to be erected at Cañon City. The works were designed to treat 500 tons of ore per day, to be later enlarged to 750, or even 1,000 tons, provided the ore market justified the increase. I had intended to use the roasting process with some important modifications and improvements which were developed during my experience at the works of the Metallic Extraction Co., and tested to finality on a working scale at that plant The estimate of the actual cost of milling the ore, extracting the values, and marketing the bullion on a basis of treating 500 tons per day, worked out to $1.75 per ton of ore. The proposed new method of treatment not only substantially reduced the working cost, but gave also an increased extraction over that attained at the old plant.

On the strength of this discovery and on the improvements that could be made in a new plant, a site for the proposed works was selected near Cañon City, and the Florence & Cripple Creek Railroad extended a branch into that city to accommodate the plant; however, before the new road was completed both the Metallic Extraction Co.'s works and the railroads were under option for sale, and were subsequently sold, which caused the scheme for the cheap milling of Cripple Creek ores to fall through,

and with it, for a time at least, the prospect of treating $5 ores at a profit to the miner

It is true that those results have not been attained in practical working on a commercial scale, but, nevertheless, there is no question as to their accuracy or of the fact that Cripple Creek ores can be roasted and cyanided in a modern up-to-date plant of 500 tons daily capacity at a cost of $1.75 per ton. But one need not enter into the question of the total cost of cyaniding Cripple Creek ores in order to compare the Diehl with the roasting process now in use. I believe the following will suffice

Diehl Process	Cost	
Bromo-cyanogen and royalty	$1 00	
Fine grinding	50	
Filter-press work and agitation	1 25	
Total		$2 75

Roasting Process	Cost	
Roasting	$0 50	
Tank work	0 25	
Total...		$0 75
Difference in favor of the roasting process.		$2 00

Assuming the cyanide consumption to be the same in each case, it is evident that the cost of bromo-cyanide, plus grinding from 30-mesh size to 200-mesh size, plus filter-press work, plus concentration, would have to aggregate less than $1 per ton before the Diehl process could compete successfully with the roasting process in the treatment of Cripple Creek sulpho-telluride ores Therefore, the latter process must prevail at Cripple Creek, as, in my opinion, it will ultimately prevail at Kalgoorlie.

THE DIEHL PROCESS *

(October 3, 1903)

The Editor:

SIR — Before venturing to discuss some points in Mr. Hoover's valuable contribution,[1] I desire to disclaim any aversion to filter-press treatment, I simply deplore its cost and gladly welcome any improvement looking toward the cheapening of filter-press operations. I might add, I have two plants under way in which filter-pressing will be a prominent feature, one of them decided on over 18 months ago Moreover, I have no aversion whatever to the bromo-cyanide or Diehl process, nor have I any interest in it or against it to warp unconsciously my judgment from the path of strict scientific comparison

At the time I wrote the article with which Mr. Hoover joins issue, the paper by Mr Knutsen gave the only complete data at my disposal, and indeed my discussion of the bromo-cyanide process was based on Mr. Knutsen's figures. These figures, I am now told by Mr. Hoover, are three years behind, and possibly erroneous. The figure $7 86 is the cost at Lake View Consols for August, 1901, taken from the directors' report, while the cost at Hannan's Brown Hill for the month of July, 1901, is given by Mr. Hoover's representative as $5.77 on the authority of Mr. Knutsen. These dates, it will be observed, are but 19 and 20 months, respectively, previous to the month chosen by Mr. Hoover for an exhibition of the detailed cost of the bromo-cyanide process. It is of the first importance to bear these dates clearly in mind while following the meteor-like advance of this interesting and evanescent process.

In a communication dated March 3, 1903, which was published in the ENGINEERING AND MINING JOURNAL of March 21, page 437, Mr. Hoover describes the bromo-cyanide process (for the

*** In connection with this article reference should be made to Mr. Hoover's article on page 39 of this book.**

[1] *Engineering and Mining Journal*, Aug 15, 1903.

introduction of which, into West Australia, his firm is responsible) in the following words "The process, in general, undertakes to extract the gold from telluride ores without roasting." Mr. Knutsen states in his paper that Mr. Diehl and himself came to the conclusion, in 1898, that for the successful treatment of Kalgoorlie ores "it would be necessary to eliminate the roasting of the raw ore, and this led us to the evolution of the Diehl process."

Now, I stoutly maintain that on this non-roasting basis the Diehl process has not scored a success, and that its progress and advance has followed the adoption of roasting the raw concentrate, rather than attacking the raw sulpho-tellurides with cyanogen bromide We could scarcely find better evidence of this than the statement in Mr. Hoover's last letter. "The yield was about $14 per ton, the extraction 92 per cent, and of this, 65 per cent was secured from the concentrates." That is to say, the savings were: by roasting, $8.372, by bromo-cyanide, $4.508; total, $12.80; and so the roasting process prevailed.

Passing now to the working costs of the bromo-cyanide (Diehl) process, I find the following data available

Mine	Period	Tonnage per month	Cost per ton
1.—Lake View Consols.	August, 1901.... ..	5,888*	$7 80
2.—Hannan's Brown Hill.	July, 1901.	2,210*	5 77
3—Lake View Consols	Prior to March, 1903	6,500*	4 30
4—Oroya Brown Hill	Prior to March, 1903	3,000*	5.30
5—Lake View Consols	March, 1903....	8,444	3 37
6.—Lake View Consols.	July, 1903	7,475	3 60
7.—Ultimate expectation.	Hoover's estimate .	12,000	2 75

These costs do not appear to include depreciation, taxes or insurance. In the above table the figures marked with the asterisk are tons of 2,240 lb. No. 4 is a heavy, rich telluride ore, difficult to treat.

Mr. Hoover states in his letter of March 3, "None of the roasting processes works under $5 per ton, and most of them 75c. to $1 above it" Yet on July 29 he writes, regarding the large roasting plants at Kalgoorlie, "The annual report from the Great Boulder for 1902 shows the cost on that mine to be $5 per ton. The Great Boulder Perseverance, treating about 12,500

short tons per month, gives 'the latest results at $3.65,'" yet these plants are by no means recent, and could, perhaps, be rebuilt or, let us say, redesigned, to advantage

To sum up Mr. Hoover's case, the Lake View treated 8,444 tons of $14 ore by the Diehl process, during one given month, at a cost of $3 37 per ton. The Great Boulder Perseverance treated 12,500 tons of probably $24 ore at a cost of $3 65 per ton The question arises, Can the Diehl process plants treat a $20 to $40 telluride ore as cheaply as the present roasting plants? I believe the consumption of chemicals in the former process might prove rather excessive However, be that as it may, I notice the exponents of the Diehl process, in such comparative statements as they favor us with, show a marked partiality for low-grade ores.

I am not familiar with the dry-crushing practice at Kalgoorlie, but have no hesitation in saying that drying and crushing the ores for the roasters can be done just as cheaply in a modern roll plant as wet-crushing with stamps, the detailed cost of which Mr. Hoover has given. Wet grinding after roasting should also favor the roasted product, provided tube mills were used, therefore, I cannot agree with Mr. Hoover that the alleged economies, which chiefly avoid drying the ore and roasting 94 per cent of it, can, by substituting concentration, bromo-cyanide, and royalty, be accomplished for $1.30 per ton less than a dry-crushing plant could handle the same class of ore and tonnage The day should be near at hand when Kalgoorlie ore, treated in a modern up-to-date plant of 8,000 to 10,000 tons monthly capacity, can be roasted for 75c. per ton. Furthermore, a roasting plant can handle any grade of ores that may be met with in the future development of the mines. For these reasons I believe that the roasting process "will ultimately prevail at Kalgoorlie."

"There is nothing novel in the Diehl process," as Mr. Hoover states, apart from the application of bromo-cyanogen to the finely ground tailings from the concentrators. These matters are well understood by some of the largest Cripple Creek mine operators, and also that Cripple Creek ores can be cyanided without fine grinding, filter-pressing, bromo-cyaniding or royalty, at a cost not exceeding $1.75 per ton. They also realize that the best metallurgical results can invariably be secured from a mixture of

ores. Consequently I look for future developments at Cripple Creek along the lines of co-operative milling, through which the most economic results can be secured, and the milling profit retained by the mine-owner members of the co-operative association.

PHILIP ARGALL

Denver, Colo., September 8, 1903

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